Petroleum Processing

INCLUDING PETROCHEMICAL SECTION AUGUST, 1955

IT'S TIME TO TAKE A NEW LOOK AT

CATALYTIC REFORMING

Special 48-page report
Starts on pg. 1157

PLUS 62 PAGES of your regular editorial menu, including . . .

INHIBITOR SWEETENING—Where it will work and where it won't . . . . . p. 1146

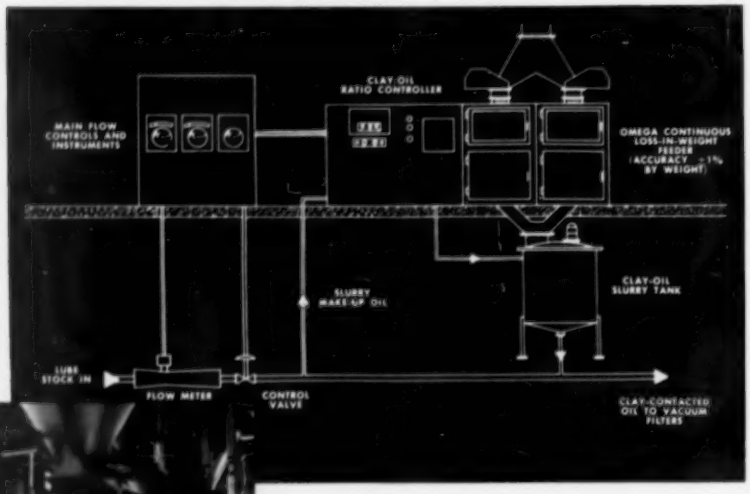
AZEOTROPIC DISTILLATION—A key tool for oxygenated chemicals . . . . . p. 1217

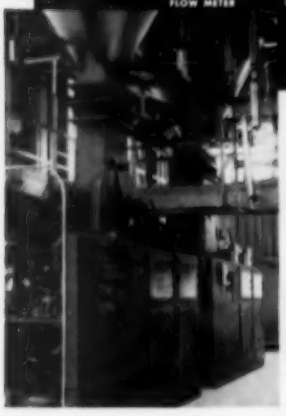
and YOUR NEW "READER'S GUIDE"—It's different. It's helpful . . . . . p. 1090

A McGRAW-HILL PUBLICATION

B·I·F METERS FEEDERS CONTROLS

for the PETROLEUM industry





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Omega, working with a refinery's consulting and contracting firm, developed this continuous clay contacting system for controlled decolorization of lube stocks. The complete system including controls, meters, Continuous Loss-in-Weight Feeder, hoppers, and slurry tank was furnished as a "package" – backed by Omega's engineering, manufacturing, and service organizations.

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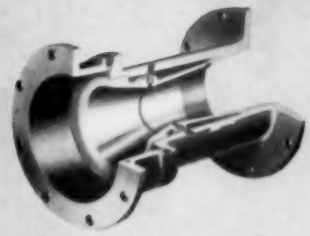
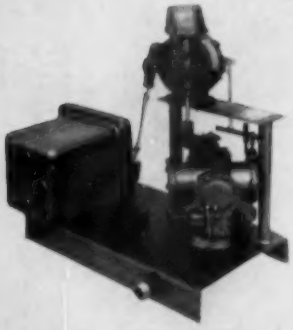


Differential producers for liquids and gases



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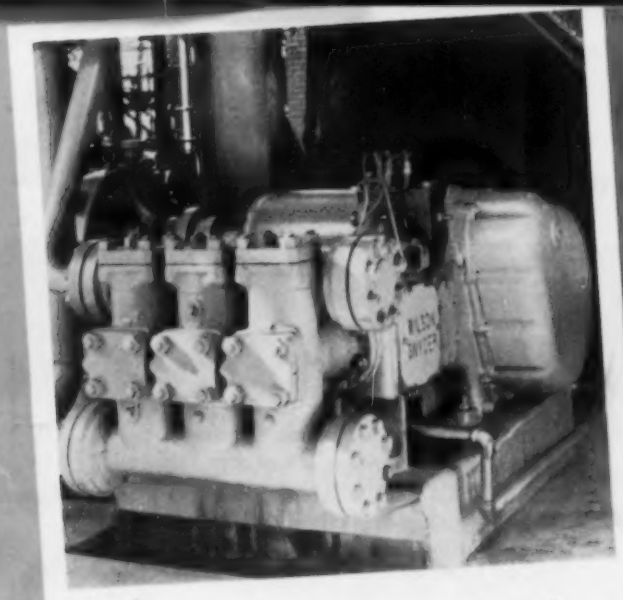
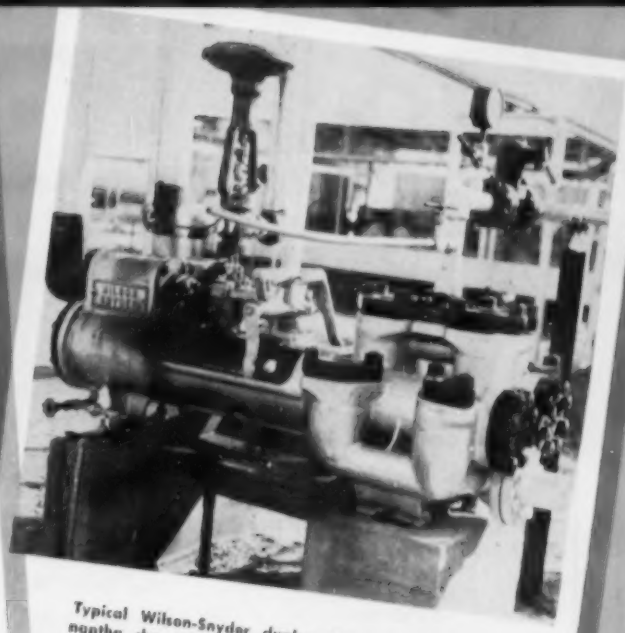


Typical Wilson-Snyder triplex plunger power pump in Universal Oil Products Platforming reactor charge service.



Typical Wilson-Snyder duplex steam pump handling naptha charge in an Atlantic Catforming installation.

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It's NEW! This "Reader's Guide" section for PETROLEUM PROCESSING, designed to help you choose more quickly the articles you want to read. Look for it in this same spot each month.

READER'S GUIDE

What's New in Petroleum

PETROLEUM REFINING | PETROCHEMICAL MANUFACTURING | GAS LIQUIDS RECOVERY | RESEARCH & DEVELOPMENT | DESIGN & ENGINEERING | PLANT OPERATION | MAINTENANCE & CONSTRUCTION | MANAGEMENT & PERSONNEL

A Boom is On in Japan's Refining

Outlook is bright with demand climbing at a 10% per year rate and consumption on the upswing since 1950, a report by the Editors, telling where the refineries are, how big they are, and their plans

p. 1139

I II 2 3 5

Predicting Volumetric Behavior

Here's help for the design engineer – How to use van der Waals and Wohl equations in such problems as these: compressor or fluid flow calculations, or sizing those fractionator columns, and the like, by Merk Hobson and James H. Weber

p. 1143

I II III 2

What Makes Inhibitors Work?

Fundamentals of the chemical mechanism of inhibitor sweetening, the widely used process for removing the unwanted mercaptan odors from cracked gasolines, by L. D. Rampino and M. J. Gorham

p. 1146

I III 1 3

Another Underground Storage Idea

Sub-surface petroleum storage, using a water seal, will help lick such problems as evaporation losses, leak, high upkeep and maintenance costs; an on-the-spot report of a new and successful Swedish scheme

p. 1150

I III 2 3 4 5

Handling a "Hot" Pipe

The project Esso Research & Engineering had to handle in preparing and transporting to their new atomic energy laboratory one tiny piece of cobalt pipe which had been exposed to radioactive rays for more than 2½ years

p. 1152

I II III 1 2 3 4 5

Technical Tips for the Processor

Questions and answers on all types of refining problems, tape-recorded for you by the Editors at a day-long session during a meeting of the Western Petroleum Refiners Association, the sixth and last installment in your 1955 series

p. 1154

I 3

Economic Ethylene Production

Detailed results of performance tests on a new type of process furnace, the temperature-gradient heater, in ethane pyrolysis service, by J. T. Karbosky, M. L. Henderson, and M. R. Kitzen

p. 1211

I II 2 3

Key Tools for Making Petrochemicals

Azeotropic and extractive distillation are key processes in making the complex separations required in recovering pure oxygenated hydrocarbon chemicals. Here's some helpful information on how these techniques can be used

p. 1217

II 1 2

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Member of Associated Business Publications and Audit Bureau of Circulations

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Processing for August, 1955

A Special 48-page Report

It's Time to Take a New Look at CATALYTIC REFORMING

Where can you apply it in your operations?
Who is operating, building or planning units?
What processes are available for your use?
Do you need more information on the subject?

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Starts on pg. 1157 . . . . . Complete contents on pg. 1158

Catalytic Reforming as a Source of MOTOR FUELS

The capacity today — and its 10-year potential. How it will be influenced by existing limitations, the octane race, possible new charge stocks, and process improvements that are in the offing p. 1160

I III 1 3 5

Catalytic Reforming as a Source of AROMATICS

In the next 20 years, petroleum's share of the aromatics market will rise 270%, and the market itself will almost triple. What is the potential for the specific products? What's the competitive outlook? p. 1162

I II III 1 3 5

Catalytic Reforming as a Source of HYDROGEN

Tips to help you choose the proper outlet for your by-product hydrogen – for upgrading feed stocks and products, for making ammonia and other petrochemicals, for sale to other users. p. 1164

I II 1 3 5

Census of Catalytic Reforming

A complete listing of all the units in operation, under construction, or planned – in the U. S. and Canada. Gives locations, types and capacities of reformers, uses of products p. 1166

I II III 2 3 4 5

The Catalytic Reforming Process

How it works and the processes you can use. Here's a 6-page appraisal of the entire subject, followed by 21 pages of process details, flow charts, photographs and tabular data on 12 specific processes—all in one convenient "package" p. 1170

I II III 1 2 3

How to Recover the Aromatics

Now that you have the catalytic reformate, what next? If you want to separate the aromatics, here are five processes from which you can choose. Gives details on how they work, operating conditions, process flow, yields, product specifications p. 1197

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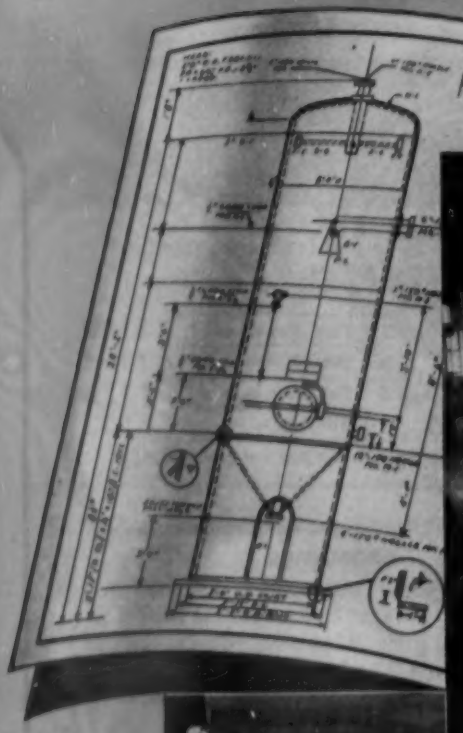
How to Use It: Your new "Reader's Guide to What's New in PETROLEUM PROCESSING" will do two things for you. First, the key numbers with each article will tell you at a glance if it is within your scope of interest; Roman Numerals indicate industries; Arabic Numerals, fields of activity. Second, the longer descriptions will tell you what each article is about, and why it can be of help and interest to you. —THE EDITORS

You DESIGN 'Em...We'll BUILD 'Em...



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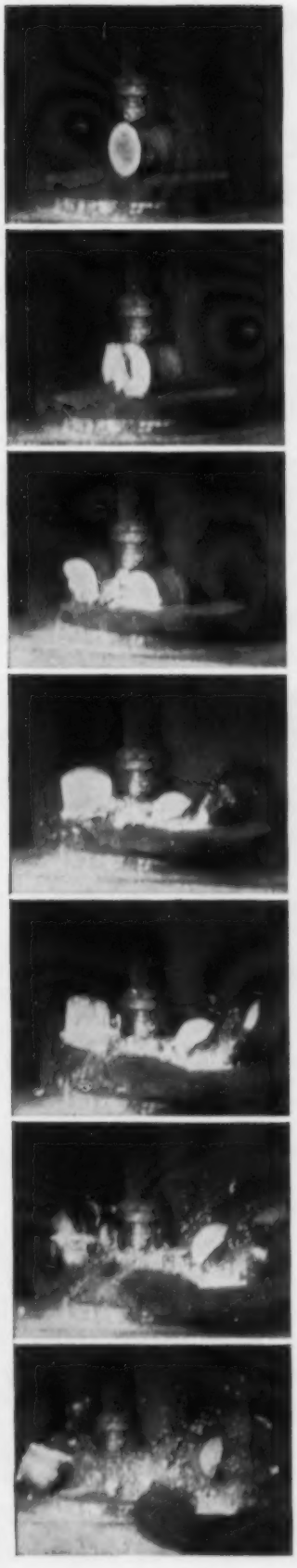

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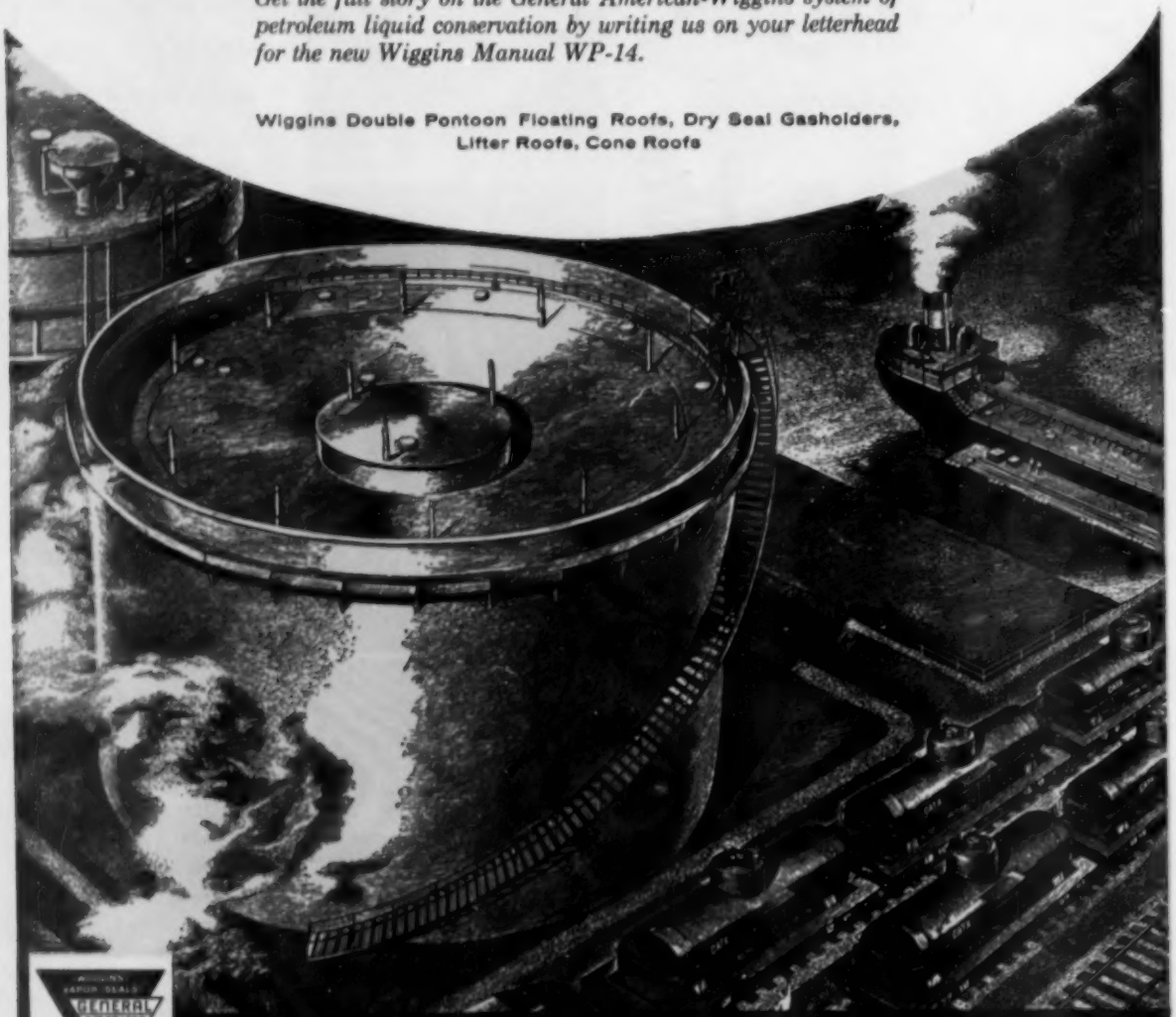

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Publisher's Page

"It's Ohhh-nly the Beginning, Folks

IF you should find your copy of this issue slightly damp, don't be too quick to accuse the postman of having left it in the rain. That dampness is just a bit of residue from the "blood, sweat and tears" which went into the preparation of two new features making their debut in PETROLEUM PROCESSING this month.

The first one you've probably already seen and studied. That's our revised and enlarged contents or "reader's guide" pages. This new "guide" has been designed to do a real job for you—to help you choose your reading material more quickly and accurately. Aside from just listing the articles in an issue, it will give you a concise description of each one. But you don't even have to read each abstract. By simply checking the keyed numbers, you can pick out at a glance those stories dealing with subjects within your own fields of interest.

The second new feature you may not have yet studied, but I don't believe you could have missed noticing it; it sticks out (as it was meant to) like the proverbial sore thumb. That's our special 48-page report on Catalytic Reforming, beginning on p. 1157, and I assure you the only sore points about it are the finger tips of the staffers who pounded out the hundreds of pages of copy that went into it.

These things don't just happen, of course; like new process units, they have to be planned, designed, and engineered. We began sweating out the contents revamp last winter, and worked up and threw out a dozen basic layouts before we hit on one that did the job we wanted done. The special report grew out of a memo dated Jan. 21 from Virg Guthrie. Then he, Bob Davidson, and Bertha Herrmann spent the better part of three months compiling the data for this comprehensive, organized and up-to-date "Appraisal of Catalytic Reforming."

The new contents pages you can count on for every issue. The special reports won't be published quite that frequently—but we've got three more of them already in the works.

These are only the first of a lot of new things planned for PETROLEUM PROCESSING. They are only the beginning of a comprehensive program to make this magazine even bigger and better than it has been in the past. More than anything else, I and the rest of my staff want you to find so much material of value and interest in PETROLEUM PROCESSING that you can't afford to miss a single issue.

William F. Bland

Editor

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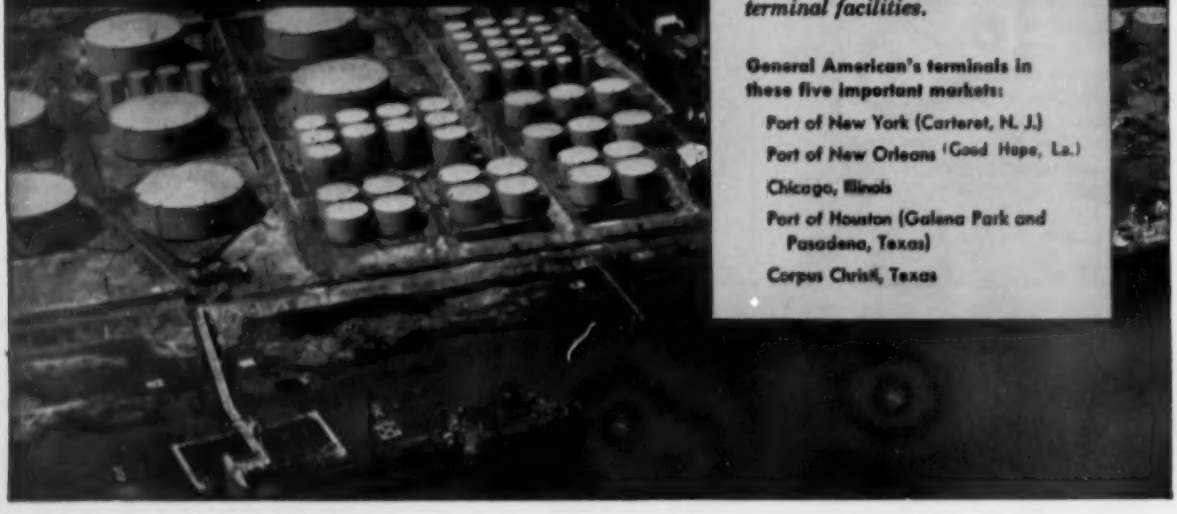
- Chicago, Illinois
- Port of Houston (Galena Park and Pasadena, Texas)
- Corpus Christi, Texas



What's Happening

in Refining

. . . **Total catalytic reforming capacity will reach** 1,302,400 b/d in U.S. and Canada by end of 1956, according to a complete census and appraisal just finished by PETROLEUM PROCESSING. Capacity operating right now is 914,100 b/d, with 388,300 b/d under construction or planned. For complete details, see special 48-page report beginning on p. 1159.

. . . **American Gilsonite Corp.,** jointly owned by the Barber Oil Corp. and Standard Oil Co. of Calif., plans to build a new plant in western Colorado using new process for refining "Gilsonite" hydrocarbon, making coke by a delayed coker and high octane gasoline by a catalytic reformer. Company holds large deposits of the solid material at Bonanza, Utah. Refinery is to be completed in late 1956.

Complete project, including expansion of Bonanza mining facilities and laying a pipe-line to new plant, is estimated at cost of over $10,000,000. Gilsonite is to be mined by a new hydraulic method and transported as a water suspension in pipe-line to the new refinery, which will have initial capacity of 600 to 700 tons of Gilsonite per day.

. . . **U.S. Oil & Refining Co.,** successor to Pacific Oil & Refining Co., will build new 15,000 b/d refinery at Tacoma, Wash., with completion scheduled for Dec., 1956, and possible later expansion to 25,000 b/d.

Crude supply is reported to be coming from General Petroleum Corp. and products to be marketed by Time Oil Co. Company president is E. E. Lyder, formerly manager of El Segundo, Calif., refinery of the Standard Oil Co. of California.

. . . **Cities Service Oil Co.** will install first Rexforming unit (UOP's new modification of Platforming) at Ponca City, Okla., a 6000 b/d unit. Completion date and contractor have not yet been set.

. . . **Derby Refining Co.** will spend $700,000 for expansion at Wichita, Kans., principally for a 2500 b/d Ultraformer, designed for a later capacity boost to 4000 b/d and conversion to aromatics production. J. F. Pritchard & Co. has contract, with completion planned for January, 1956.

. . . **Western States Refining Co.** will build a new 1000 b/d catalytic reformer and a 2000 b/d asphalt unit at its Salt Lake City, Utah, refinery, for an investment cost of $1,200,000.

. . . **Utah Oil Refining Co.** has given contract for design and construction of its new 5500 b/d Ultraformer at Salt Lake City, Utah, to Fluor Corp. Cost is about $3,000,000.

. . . **Anderson-Prichard Oil Corp.** has awarded contract to Southwestern Engrg. Co. for construction of a $750,000 Platformer of 5000 b/d capacity for its Arkansas City, Kans., refinery, with completion scheduled for late October.

. . . **Jefferson Lake Sulphur Co.** will build a plant for processing natural gas to liquid hydrocarbons at the Bayou Sale field in St. Mary's Parish, La., with a capacity of 40,000,000 cfd. Atlantic Refining Co. will furnish its gas from same field and share in the natural gasoline and other recovered products.

. . . **Cosden Petroleum Co.** will build a 3900 b/d catalytic reformer at Big Spring, Texas. This is in addition to an existing 4500 b/d Platformer-Udex unit which is to be shifted to 100% aromatics production. Company is also revamping its 10,000 b/d Fluid cat cracker at cost of $935,000, upping throughput to 13,000 b/d of virgin gas oil.

. . . **Imperial Oil Ltd.** at Sarnia, Ont., will replace existing thermal reforming units of 10,000 b/d total capacity with a new 13,500 b/d catalytic reformer, for probable completion by October, 1956.

. . . **New construction projects** approved for fast tax write-offs recently include the following:

National Cooperative Refinery Association, $1,165,000 for a 4200 b/d Platformer at McPherson, Kans.

El Dorado Refining Co., $796,000 for a 2500 b/d Platformer, and two 80,000-bbl. storage tanks at El Dorado, Kans.

Shell Oil Co., $220,000 for an 8,000 b/d thermal cracking unit at Norco, La., $9,550,000 for a 15,000 b/d catalytic reformer and auxiliary facilities at Houston, Texas, and $904,500 for maintenance facilities at Wood River, Ill.

Standard Oil Co. (Indiana), $840,000 for steam generation facilities at Mandan, No. Dak.

in Petrochemicals

. . . **Phillips Pacific Chemical Co.,** a new firm owned jointly by Phillips Petroleum Co. and Pacific Northwest Pipeline Corp., will build a new 200 ton/day anhydrous ammonia plant in southeastern Washington, with design by Phillips Chemical Co. and construction by Fish Engrg. Corp., and completion scheduled for late 1956.

Arrangements have been made with the pipeline company for 15,000,000 cfd of natural gas as the raw material, to be transported from San Juan Basin of New Mexico via a new line being built, bringing the first natural gas into Washington, Oregon, and Idaho territory.

. . . **Celanese Corp. of America** will build a new petrochemical plant at Gallipolis Ferry, near Point Pleasant, W. Va., with C. F. Braun & Co. holding engineering and construction contract.

Among products will be tricresyl phosphate, with April, 1956, set as target date for first onstream operations. Some raw materials will come from firm's Texas plants: others will be derived from assured petroleum and coal tar sources.

. . . **Shell Chemical Corp.** will build a new 100 ton per day urea plant at Ventura, Calif., with completion scheduled for Sept., 1956. Process has been licensed from Montecatini (Italian firm) and contractor is M. W. Kellogg Co.

. . . **B. F. Goodrich Chemical Co.** has awarded a contract to Girdler Co. for engineering and construction in connection with expansion of synthetic rubber facilities at Louisville, Ky.

. . . **Reichhold Chemicals, Inc.,** indicated plans for long range expansion with recent completion of a $10,000,000 combination bank loan and debenture. Need for growth was made clear, company said, when it found itself completely committed for balance of this year on all basic chemicals it can produce except phenol and pentaerythritol. Products unavailable till 1956 include phthalic anhydride, maleic anhydride formaldehyde, glycerine, among others.

. . . **Deep Rock Oil Corp.,** scheduled to change its name to Crescent Corp. by stockholders' approval late last month, is "continuing to search actively for attractive investment opportunities in the fields of petrochemicals and engineering," although it sold refining interests to Kerr-McGee a few months ago and currently is most active in oil and gas producing.

in Foreign Operations

. . . **British Petroleum Chemicals Ltd.** has awarded Stone & Webster Engrg. Corp. design and construction contract for ethylene, ethanol, and tetramer units at Grangemouth, Scotland, at cost of about $13,000,000.

. . . **Deutsche Shell A.G.** plans to boost capacity of its 14,000 b/d Harburg, West Germany, refinery to 52,000 b/d. Units will include a cat cracker, hydrodesulfurization unit, and a second Platformer.

. . . **Shell Oil Co.** and Ceylon Government negotiations over the establishment of a refinery near Colombo, deadlocked a few months ago because of concessions asked by Ceylon, have been renewed as a result of new proposals made by Shell.

. . . **First European butadiene unit** using new Houdry dehydrogenation process is to be installed by Chemische Werke Huels A.G. at Marl, Kreis Recklinghausen, West Germany, with annual capacity of 36,000 metric tons. Houdry has process engineering contract. No builder has yet been named.

. . . **Brown Lite Co.** of Tulsa, Okla., has approached government officials in San Salvador on possibility of establishing a multi-million dollar refinery in that country.

in Transition

. . . **Tennessee Gas Transmission Co.** has completed purchase of major portion of assets of Bay Petroleum Co., Denver, and personal holdings of former president C. U. Bay, for approximately $20,000,000.

Expansion and modernization at cost of $1,250,000 has been started for refineries in Denver and New Orleans.

. . . **Texas National Petroleum Co.** will be name of new firm resulting from merger of Johnston Oil and Gas Co. and Texan Oil & Gas Co., provided stockholders go along with recent merger OK by directors.

in Markets and Prices

. . . **Contra-seasonal price trends for heavy fuels** and gasoline topped the market news in July. Residuals were quoted higher, while in the East, wholesale gasoline prices were down. Distillate fuels were a dead issue, with prices easy. Lube oils had stiffened, and prices pointed upwards for the first time in several months.

. . . **There was no easing in heavy fuel demand.** Eastern marketers, trying to hold down imports, continued to tap California for supplies. Esso Standard purchased an estimated 1,000,000 bbl. in addition to 3,900,000 bbl. bought in June, and one large eastern independent booked four cargoes for East Coast delivery.

. . . **Prices were up for ordinary bunker oil,** 15¢ a bbl. along the East Coast. For maximum 1% sulfur oil, prices jumped 30¢. Caribbean refinery prices for cargo lots were up 15¢ and, at mid-month, the Gulf Coast cargo price also pointed upward. In the Mid-Continent, No. 6 fuel was up 5¢ a bbl. to $1.75, Group 3.

. . . **Gasoline was firm to strong in the Midwest,** and prices appeared firm at the Gulf for perhaps the first time this year.

But in the East it was a different story. Socony Mobil touched off a general reduction of 0.3¢ to 0.5¢ a gal in tank wagon prices in New England, five other eastern states, and the District of Columbia. The many price wars in the East dictated general adjustments in prices, Socony said. Major suppliers met Socony's reductions generally.

Quotations for Grade 26-70 natural gasoline rose 0.5¢ in the Mid-Continent, with sales reported at 5¢, Group 3, and 4.5¢, Breckenridge. Increased demand from refiners prompted a 10¢ a bbl. advance in Pennsylvania-grade crude oil postings by South Penn Oil Co. New price for Bradford district crude was $3.60 a bbl.

"Completed by more than 7,000 Indian workers in the record time of eighteen months, despite two of the worst monsoons in Bombay's history, India's first major multiproduct refinery has imparted added firmness to the total economic picture of the country."
Bombay's Two Worst Monsoons

YET LUMMUS FINISHED 6 MONTHS AHEAD OF SCHEDULE

The first large, modern refinery in all India — with a crude capacity of 25,000 B/D — was completed by Lummus in July 1954 for Standard-Vacuum Oil Company.

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One hundred sixty inches of rain fell in the area during the 1953 monsoon, and 180 inches in 1954, creating special drainage and grading problems and seriously interfering with work schedules. Insufficient roads made necessary the moving of heavy vessels by barge. Hundreds of the 7,000 Indian workmen employed on the job had to be trained in skills and construction techniques new to that country.

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Grade	F-3-25 Extra Fine	F-2-25 Fine	F-1-25 Inter-mediate	C-1-25 Coarse	C-2-25 Extra Coarse
Size range by C.A.E.: Wt. %					
0-10 Microns	4	2	1	1	1
0-20 Microns	9	4	2	2	2
0-30 Microns	16	11	6	5	4
0-40 Microns	28	21	12	10	8
. . . and a minimum of coarse particles					
Sieve analysis: Wt. %					
on 100 mesh (149 microns)	0	0	1	1	1
on 140 mesh (104 microns)	1	1	4	6	8
on 200 mesh (74 microns)	4	5	15	22	33

Now Davison has taken the characteristics of High Alumina Catalyst and combined them with the proven advantages of its 13% Alumina Catalyst. This gives you, for the first time, High (25%) Alumina Catalyst with *all* these qualities:

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Watch for Still More Continuous Processing of Petrochemicals

CONTINUOUS processing, the economic and technological heart of the petroleum refining industry, has not been nearly so widely adopted for all types of petrochemical manufacture.

True, the giants among products—like ethylene—were quickly and readily adaptable to production by continuous methods. But many products are relatively small volume, specialty items, in no way approaching the scope of operations in conventional refining. Economics seemed to favor use of batch operations. High first costs soon discourage manufacturers who otherwise were intrigued by relatively low operating costs.

But now comes another petrochemical product—synthetic detergents. Batch sulfonation plants have been doing a good job. Manufacturers have been loath to toss them out. Recently, however, several have been looking with interest at some newer continuous techniques.[1]

One process, a development by Chemithon Corp. of Seattle, Wash., is being investigated for alkane sulfonation by Oronite Chemical Co. Girdler Corp. has just finished an installation of its Votator equipment (already in the continuous grease-making field) in a semi-works plant that's sheduled for full-scale expansion this year.

Big advantage claimed for the continuous method of sulfonation is equipment can be small compared to output capacity: process stream moves through fast. But, this created a heat dissipation problem since the reaction is highly exothermic. Chemithon's solution was rapid mixing to minimize contact time between alkane and the sulfuric acid.

As a result, process cycle time was cut from 10-13 hours (normal or bath operation) to 13 minutes.

Another advantage cited by Chemithon is their figure on low initial cost. They calculated that a 2,000,000 lb/yr unit (size of their pilot plant) would represent an investment of about $25,000. A batch plant of the same size would run between $60,000 and $75,000.

Couple these factors with compact equipment size and fact that continuous operation lends well to automatic control and you have several reasons for a company like Oronite to be interested.

In the case of the Votator system, two goals are being aimed for: accurate control of mixing conditions and regulation of reaction temperature precisely.

Specialty detergents can also be processed in the Votator, it is said, because of the unit's ability to control sulfonation using sulfur trioxide as well as oleum.

Although sulfur trioxide is tougher to work with, it offers a number of advantages:

1—The mole-per-mole reaction leaves no excess acid to be neutralized.

2—Highly pure, salt-free product is obtained without expensive further refining.

3—Sulfonates can be easily neutralized to triethanolamine salts or other special salts as required.

4—The reaction works on many other organic compounds, such as mercaptans or fatty alcohols, and the oleum process can't handle these.

There's still a good bit of resistance, as can be expected, from the smaller specialty houses in the field. They feel batch operations are quite satisfactory for small volume processing. But, it seems safe to predict new ventures in synthetic detergents will take a close look at continuous sulfonation.

—WCU

(1) "Syndets Go Continuous," *Chemical Week*, July 2, 1955, pp. 66-67.

Add New Uses for Petrochemicals —Structural Material for Homes

UP TO now, multi-cellular plastic foam type materials produced from polystyrene (in turn derived from benzene and ethylene via ethyl benzene) have been found to be excellent as low temperature insulation. The "K" factor of one such material, "Styrofoam," is 0.23 to 0.30 Btu/sq. ft./hr/°F/in., equivalent to that of cork.

A couple of enterprising Texans, however, have taken another physical property of this material—its structural strength—and turned it into an advantage in a new use: load-bearing exterior walls for residential housing.

Significance of this to the builder is that he can provide an insulated wall capable of withstanding approximately 3000 psi. load, and for a cost of about 85¢/sq.ft. This compares to a cost for a brick veneer and insulation wall of about $1.25/sq.ft., a tidy savings according to a number of Houston building contractors.

Furthermore the material is light—easy to handle and use in a building job. One cu. ft. weighs about 2 lb., whereas the same volume of many structural woods will frequently run in the neighborhood of 30 lb.

Significance to the home-buyer is three-fold. He can gain in lower first cost, in decreased maintenance, and in reduced heating bills or air-conditioning charges. Use of the Styrofoam in walls, flooring, and roof could yank as much as $1000 off the price of a $12,000 to $14,000 house. And suppliers see the price of the polystyrene foam coming down as demand rises.

The lower heating costs are a direct result of the insulation properties: it takes about 80,000 Btu/hr compared to 150,000 Btu/hr for conventional construction in homes of equal size. As for air cooling; estimates show a house with the plastic to have about 60% of the refrigeration requirement of a house with regular construction. With respect to maintenance, experimenters observed a small tool-shed which has held up under two years of weathering with no signs of rot or deterioration.

The complete "plastic" house will not only have the polystyrene material in the walls, but floors and roof as well. Plans for the floor in at least one large

room are for a 1-inch thick slab of the material bonded with oxychloride cement to a ¼-inch thick square of marble, and laid directly on the cement slab of this basementless house. The cost is estimated at about one-third that of the conventional marble flooring.

A four-ply, built-up job will comprise the roof, covered with shingles of Styrofoam, measuring 9 x 18 in. These shingles are 2½-in. thick at one end, and 3¼-in. thick at the other. Cost is estimated at about the same as for a conventionally shingled roof of equal size.

Significance to the petrochemical industry is in the new potential market for polystyrene, and thus for ethylene and benzene. Suppose, for example, that polystyrene foam could win about 5% of today's market for wood for house construction where it will serve, estimated at 5,670,000,000 board feet for 1955. In weight equivalents, this would mean about 47,250,000 lb. of polystyrene.

Benzene and ethylene producers therefore would seem to face a continuing bright future, should the plastic house idea really take hold. Further details on the house itself are given on p. 1221. The idea is a development by Dean Emerson, of The Emerson Co., who are distributors of Styrofoam in six states including Texas, and Francis J. Niven, a Houston consulting engineer.

—WCU & DPT

New "Wet" Fischer-Tropsch Reactor Makes Cheaper Synthetic Fuels

ECONOMIC synthesis of liquid fuels from coal by the Fischer-Tropsch process appears closer today as the result of recent semi-commercial scale work by engineers with Germany's Rheinpreussen A. G.[1]

By using a "wet" reaction system, they have been able to circumvent process disadvantages from the use of hydrogen-poor coal synthesis gas. Carbon deposition and catalyst deterioration are avoided, and the need for recycle hydrogen is eliminated.

The wet reaction system consists of a finely divided, precipitated iron catalyst, suspended in a liquid hydrocarbon phase, through which compressed CO and hydrogen are dispersed. Cooling is provided by evaporation of water within coils immersed in the liquid, with rapid heat exchange claimed. Heat transfer surface requirements are said to be low—less than 15 sq.ft. per 1000 cu.ft. of synthesis gas converted per hour.

Rheinpreussen claims up to 97% conversion of the CO and hydrogen in a two-stage, once-through, wet process. Products from the synthesis include 92 to 98% C_3 or greater hydrocarbons.

Koppers Co. of Pittsburgh participated with Rheinpreussen financially in the demonstration plant work, and Koppers is now the exclusive licensor for the entire western hemisphere and certain other countries in Asia and elsewhere.[2]

Although the process is not yet competitive in this country when compared to natural petroleum products, or to the Fischer-Tropsch synthesis using hydrogen-rich gas from natural gas (at the Brownsville, Texas, plant of Hidalgo Chemical Co.); it will certainly be attractive in countries long on coal but short on petroleum. (See below.)

—RLD

(1) Kolbel H., Ackermann, P., and Engelhardt, F., "New Developments in Hydrocarbon Synthesis," Fourth World Petroleum Congress, June, 1955, Rome, Italy.
(2) Anon., "3-Phase System Keys Progress in Synthetic Liquid Fuels," *Chemical Engineering*, Aug., 1955, pp. 120-122.

New Hydrocarbon Synthesis Might Prove to Be Economic in U. S.

A NEW source of cheap carbon-monoxide containing gases for hydrocarbon synthesis has been reported by engineers of Rheinpreussen A. G. of Germany, along with their improved "wet" reaction system developed for the Fischer-Tropsch synthesis (see preceding description of the "wet" Fischer-Tropsch system).

It was that CO-lean gases—from such sources as blast furnace gas—could be reacted with water vapor to achieve a 93% CO conversion in one pass, and yield a product of 0.0125 lb/cu.ft. of CO—70-80% olefins and nearly 90% C_3 and heavier.

Such CO-lean gases have only fuel value, and at peak production levels, not even that. Therefore, if no value is assigned to this CO-lean gas, the cost of the primary products from the reaction of CO and water vapor will be only about 30% of the Fischer-Tropsch products. Even when assigning "fuel" value to this gas, the synthesis products were only about 60% of Fischer-Tropsch products.

Although the reaction had been studied previously, the tests gave only small product yields—consisting mostly of methane—and catalyst life was short because of improper selection of operating conditions and catalyst, and improper catalyst pretreatment.

The essential features of the new process include the restriction of the CO-water ratio to between 1 and 2 parts water vapor per 3 parts CO. Excess CO causes heavy carbon deposition, while excess water inactivates the catalyst by oxidation. Another feature is the dependence of allowable space velocity on pressure—a point of departure from the Fischer-Tropsch synthesis.

Examination of the gross reaction equation: $3CO + H_2O \rightarrow -H_2 + 2CO_2$, might appear to suggest a water gas reaction with subsequent Fischer-Tropsch synthesis. However, when this sequence was induced artificially, yields were much lower than with the new process.

If the laboratory results obtained thus far can be substantiated with similar yields and product qualities on a commercial scale, this new source of hydrocarbons might even prove economic in oil-rich countries like the U.S.

—RLD

(1) Kolbel, H., Ackermann, P., and Engelhardt, F., "New Developments in Hydrocarbon Synthesis," Fourth World Petroleum Congress, June, 1955, Rome, Italy.

Letters

Concrete Corrosion

To THE EDITOR: I was pleased to read the summary of my paper ("Concrete Deterioration—A New Corrosion Engineering Problem") in PETROLEUM PROCESSING (June, 1955, pp. 779-780). I am sure this will serve to caution the refining industry that this type of corrosion can occur under certain conditions in a refinery condenser water sewer.

I would like to call attention to the last paragraph of the summary, particularly the sentence "It is impossible to verify their prior existence in the early stages of the corrosion process, inasmuch as these bacteria cannot be identified at the analysis of the final corrosion products."

As indicated in my paper, we have positively identified the existence of sulfur oxidizing bacteria (Thiobacillus Thiooxidans). These bacteria are responsible for the production of high concentration of sulfuric acid with the resulting low pH. The bacteria whose existence it is impossible to verify are those possibly active in the early stages, i.e. Thiobacillus, and indicated by "B" on the probable corrosion curve.

JOHN ZAHODNICK

Linden, N.J.

LPG Copper Strip

To THE EDITOR: . . . During the course of an investigation involving corrosive propane at our plant, we read the comments by Dr. Charles W. Rippie ("Technical Tips on Petroleum Processing Problems," April, 1955, p. 520) in replying to a question as to causes of LPG copper strip corrosion and methods for its prevention.

We would certainly appreciate any additional information concerning this subject, particularly with respect to the formation of oil-soluble soap. This is an entirely new aspect of the LPG copper corrosion thinking at this plant.

GEORGE H. UNZELMAN
Resident Chemist
Continental Oil Co.
Billings, Mont.

• *Dr. Rippie has been kind enough to pass on his reply to this query for the readers of* PETROLEUM PROCESSING:

For a number of years I was associated with the Shell Oil Co. in chemical treatment of distillate stocks.

No. 304 . . . easy to set-up . . . fast to use . . . precision made . . . gives perfect threads every time.

No. 4P geared die stock gives perfect threads on 2½" to 4" pipe with four sets (5 each) of dies.

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Small Ratchet threaders capacity from ⅛"-2".

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SPECIFY THE RIGID "502" . . .
for use on any power drive. Single set of self-contained dies adjusts quickly to ½" and ¾" pipe . . . regardless of position of quick opening lever.

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HERE'S THE *New* RUPTURE DISC FOR BS&B SAFETY HEADS...

...ESPECIALLY DESIGNED FOR USE IN LOW PRESSURE APPLICATIONS UNDER SEVERE CORROSIVE CONDITIONS!

For many years the problem of producing a low pressure rupture disc that could withstand prolonged exposure to severe corrosive conditions was a perplexing one. Yet, it was a problem that *had* to be solved, particularly for the Process Industries.

Therefore, it was only natural that BS&B — originator of the Safety Head — should come up with the right answer in the form of a flat type rupture disc whose bursting pressure is controlled by a top metal section, isolated from the corrosive contents of the protected vessel by a sealing membrane of Teflon or Kel-F.

If back pressure is not anticipated, the bottom metal section of the disc is cut open to full relieving capacity (Model 1A). However, if a vacuum support is needed, the bottom metal section is constructed similar to the top section to serve as a vacuum support (Model 1B). Top and bottom sections are spot welded together to give a single compact unit.

Disc Models 1A and 1B are constructed of corrosion-resistant metals such as Inconel, stainless steel, nickel, Hastelloy B and Monel. Either model is available in 2", 3", 4", 6", 8" and 10" sizes. Pressure ratings are from 8 to 100 lbs. Close design tolerances are an inherent feature of this type disc.

If you have a pressure relief problem which you have not been able to solve satisfactorily with the regular pre-bulged type of disc or other types of relief devices, try the new BS&B Model 1A or 1B disc. It fits any standard size BS&B Safety Head flanges you may now have in service. Also available in a complete assembly consisting of inlet and outlet flanges, rupture disc, studs and nuts.

Your BS&B Man will be glad to give you details . . or you may write for descriptive literature and prices.

BS&B Safety Heads

THE "CIRCUIT-BREAKER" OF Pressured Systems

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY

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At that time, sales specifications of LPG included negative copper strip corrosion tests. This specification caused considerable trouble with corrosive propane. We were using a heavy caustic soda treatment at that time to extract all possible acid oils and to dry the LPG as much as possible. Later, the corrosive propane was corrected as outlined in my previously published comments from the Western Petroleum Refiners Association meeting.

The same general theory of sodium naphthenate oil-soluble soap is developed in furnace oils when they are treated with 15 or 20 Be. caustic soda solution. The soaps accelerate the sludge formation in treated furnace oils. The laboratory testing solution is one gm. of ferric ammonium sulfate per liter of distilled water, seettled one day, and filtered through cotton. The soap tests consist of shaking 50 ml. of treated furnace oil with 50 ml. of the above reagent in a 4-ounce bottle. If sodium naphthenate soaps are present, a ragged inner face develops and usually there is some change in color.

Have you tried to evaporate a liter of butane before and after caustic treatment with 10 and 20 Be., and with the copper strip in the evaporating flask? This simple test should assist you in checking the presence of sodium soaps which are soluble in the butane and which contribute to the corrosive copper tests.

C. W. RIPPIE
President
Electric Process Co.
Summit, N. J.

In this Issue:

Let's Take a New Look at

Catalytic Reforming

A Special 48-page report by the Editors

- If you're concerned with long-range planning;
- If you have to evaluate new processes;
- If you have to operate or maintain a new unit;
- This is for you.

Turn to page 1157

DU PONT

PETROLEUM CHEMICALS DIVISION NEWS

DU PONT

August ★ One of a Series of Interest to the Petroleum Industry ★ 1955

THIS IS THE LATEST (No. 6) in Du Pont's series of dealer-education folders, entitled "looking through the windshield."

It tells the dealer – simply and clearly – how to turn "free" services such as windshield cleaning and tire pressure checking into profitable sales . . . by being on the alert to spot smooth tires, worn fan belts and rotted wiper blades.

It points out that the one service – oil check – which is considered *most important* by a big majority of motorists, is also one of the dealer's most profitable sales opportunities. And it clearly clinches the argument for "free" services by showing that, where services are given, the average gasoline purchase is greater by almost 2 gallons in volume and 55 cents per sale, than where the motorist receives no services.

This folder on services is the final one in the series. Others discuss (1) the customer himself, (2) "regular" and "premium" purchases, (3) credit, (4) motor oil buying habits, and (5) TBA purchases.

Any Du Pont Petroleum Chemicals Division representative or regional office will be glad to give you sample copies . . . and cost information on ordering the folders in quantities for your dealers.

Heating oils with FOA-2 have built-in promotion opportunities

As competition gets keener, you need new advantages to offer your ultimate customer – the heating oil user. And you can gain many customer advantages with Du Pont Fuel Oil Additive No. 2.

Du Pont FOA-2 acts as both a stabilizer and dispersant to retard the formation of insoluble residues and break up any residues that are formed. This greatly reduces clogging of filters, nozzles, screens and lines. In this way, it contributes greatly to cleaner, *more efficient* burner operation – an outstanding customer advantage.

Cuts service calls

By preventing clogged fuel systems, Du Pont FOA-2 helps to eliminate many service calls which might otherwise be a costly nuisance for both customers and distributors.

Its stabilizing action also means that you can assure your customer of *fresh* fuel throughout a long heating season –even though long storage periods are involved.

Advantages to refiner

With Du Pont Fuel Oil Additive No. 2, you can gain added refining and blending flexibility to meet peak seasonal demands for fuel oil on short notice. This is because it enables you to blend catalytic-cracked stocks with straight-run products. Thus, it also helps you release more of your straight-run

Continuing gum problem indicates need for constant guard against copper

In spite of the numerous steps refiners have taken to prevent it, metallic contamination of gasoline can still occur to an alarming degree. One Du Pont gasoline quality survey, for example, disclosed significant amounts of copper present in 91% of 241 gasoline samples from representative service stations in the U. S. and Canada. And the gasolines known to contain no metal deactivator were found to be high in gum content.

To safeguard your gasolines against the harmful effects of copper requires only about 1 pound of Du Pont Metal Deactivator per 1000 barrels. And in this low concentration, it costs you less than 1/5 of a cent per barrel to get this effective and important quality insurance.

THIS BOOKLET has all the information you will want about Du Pont Metal Deactivator. Full details on methods of addition, as well as product properties, are included. Ask any of our representatives or regional offices for a copy.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED

Heating Oils

stocks to meet demands for high quality diesel fuel.

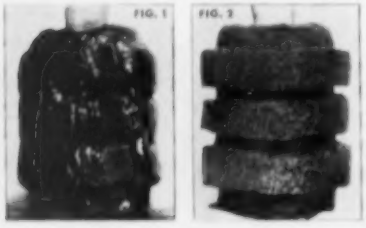
And for best results, FOA-2 should always be *added to freshly prepared stocks at the refinery.*

Low cost

Du Pont FOA-2 is effective in low concentrations – extremely economical to use. Many refiners have obtained excellent results with it at a treating cost of less than 2¢ per barrel. And when you consider the added flexibility and customer satisfaction it provides–combined with the elimination of many costly service calls – it more than pays for itself.

Promotion aid

To help you take advantage of the advertising and promotion opportunities of Du Pont FOA-2, our representatives will be glad to consult with you and provide a sample promotion built around a heating oil containing FOA-2.



Figs. 1 and 2 are representative of results obtained in a test conducted by a major oil company in an area where an abnormal number of sludge complaints in domestic heating systems were received.

Fig. 1 shows a typical filter element as removed from one of the heating units after running on untreated fuel. Fig. 2 shows an element at the end of a 90-day test period in which the same fuel plus Fuel Oil Additive No. 2 has been used in the system.

Try it!

Samples of Du Pont Fuel Oil Additive No. 2 for testing in your own stocks are readily available. And you can get complete information on it and methods of adding it from any Du Pont Petroleum Chemicals Division representative or regional office listed below.

AUTOMOTIVE TECHNOLOGIST

JOHN R. GRIFFIN, JR., a specialist in automotive and aviation fuels and lubricants, is currently working on the introduction of new additives developed by the Du Pont Petroleum Chemicals Division.

Most recently his activities have been concentrated on the introduction of the new Du Pont Lube Oil Additives 564 and 565. Prior to this assignment his specialty was additives for aviation fuels.

Before joining the Du Pont Company in 1950, Mr. Griffin was Chief Engineer at the Sharples Corporation's research laboratory at Bridgeport, Pa. There he was engaged in the development of centrifuges for classifying fine particles. His experience also includes six years with Trans World Airlines as Engineering Manager of aircraft maintenance and modification. Previous to this, he was a senior engineer at the Shell Development Company, working on the development of aircraft engine lubricants.

Mr. Griffin received his B.S. and M.S. degrees in Mechanical Engineering at the University of California in Berkeley. He is a member of the Society of Automotive Engineers, the American Society of Mechanical Engineers, and the Institute of Aeronautical Sciences.

Envelope Stuffer to Help Your Fuel Oil Distributors Simplify Their Service Problems

Efficient oil burner servicing always promotes good customer relations for your distributors. But when they have too many *needless* service calls, their profits suffer.

Since the average heating oil user automatically picks up his home phone and calls for service the minute he has the slightest trouble with his burner, it is often awkward to convince him that he may get faster results–and save money, too–by making a simple check of his equipment.

To help your distributors overcome this common problem, the Du Pont Petroleum Chemicals Division has prepared a special envelope stuffer for their use. It is tactfully written and contains no commercial message for any product . . . only a plug for the dependability of the distributor's service.

The title is "What? No Heat!" The copy gives easy-to-understand-and-remember instructions on checking

such things as fuses, switches and the fuel level in the storage tank.

For sample copies and cost information on obtaining the stuffers in quantity for your distributors, contact any of our regional offices listed below.

DU PONT
Better Things for Better Living
. . . through Chemistry

Petroleum Chemicals

E. I. DU PONT DE NEMOURS & COMPANY (INC.)
Petroleum Chemicals Division • *Wilmington 98, Delaware*

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ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

A-9792

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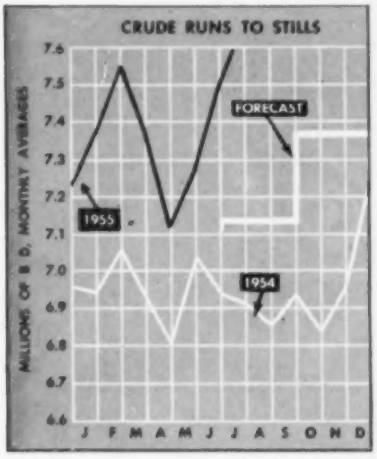
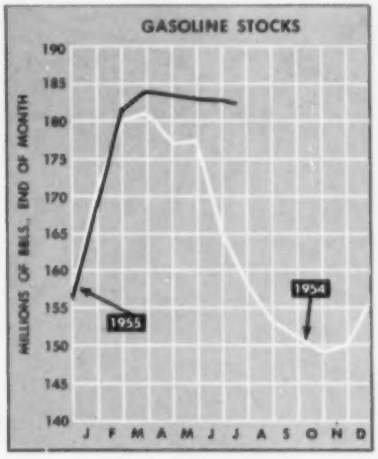
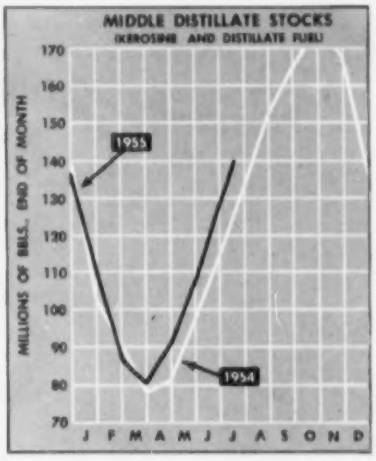






1955 figures to July 15

Storm Warning on Distillate Stocks

OUTLOOK: For sharp reductions in crude runs in the latter part of the third quarter.

REFINERY operations continue to be geared to the unanticipated high gasoline demand, in both the volume of crude run to stills and in product yields. The result is that distillate fuel oil stocks are building up at a rate that is causing concern. Some companies believe runs should be cut by 200-300,000 b/d to slow down this stock buildup.

Distillate fuel oil inventories at the end of March were about 2,300,000 bbls. higher than at the same time last year. By July 15 they were 108,932,000 bbls., 14,100,000 bbls. (14.9%) higher than July 16, 1954. A leavening factor is the fact that 8,515,000 bbls. of the current increase is in the combined East and Gulf Coast refining districts, the only consuming area in the country where there was even a threat of short supplies last winter. In inland refining districts, however, stocks July 15 were 19.3% larger than last year.

In 1954, distillate fuel oil stocks increased by about 33,000,000 bbls. from July 6 to Oct. 1. The same volume increase in 1955 would bring stocks to 142,000,000 bbls. to start October. This would be 12,000,000 bbls. above the 130,000,000 bbls. of distillate fuel oil which oil companies consider adequate to have "on the shelf" at the start of the heating season.

Coming winter demand for heating oil, the principal distillate product, based on the current rate of building construction, is estimated at 5% higher than last winter. Colder than normal weather could increase this to 8-9%.

Gasoline third quarter shipments, if they show the same rate of gain from second quarter demand as in the past two years, will average around 3,940,000 b/d, about 8% larger than in the third quarter of 1954.

Reductions in gasoline stocks at refineries are moderate when compared with last year's inventories, and these were considered unduly high. Total U. S. stocks July 16 were 158,822,000 bbls., 1.8% less than on July 16, 1954. Biggest improvement is in the inland refining districts, where storage supplies July 15 were 7.6% less than a year ago.

JULY KEY STATISTICS

(Figures given in terms of millions of b/d, monthly averages, except stocks, which are in millions of bbls. at end of month)

	July 1955*	June 1955	July 1954
CRUDE OIL			
U. S. Production	6.612	6.617	6.242
Imports	.775	.728	.724
U. S. Stocks	268.815	273.338	284.894
Runs to Stills	7.606	7.508	6.916
GASOLINE			
Refinery Output	3.725	3.670	3.385
Refinery Demand	3.963	4.075	6.723
Primary Stocks	158.307	160.306	158.010
MIDDLE DISTILLATES			
Refinery Output	1.892	1.919	1.711
Refinery Demand	1.183	1.211	1.106
Primary Stocks	140.313	129.679	133.610
RESIDUALS			
Refinery Output	1.123	1.123	1.089
Imports	.265	.296	.270
Total Supply	1.388	1.419	1.359
Refinery Demand	1.350	1.398	1.243
Primary Stocks	45.482	44.911	54.365

*Through July 15.

PRODUCT AND CRUDE PRICES

Products—¢ gal., weighted average prices in principal refinery markets
Crudes—$/bbl., principal fields
Source—Platt's Oilgram Price Service

	July 1955*	June 1955	July 1954
Gasoline	11.35	11.35	11.35
Distillate Fuel Oil	8.89	8.98	8.66
Kerosine	10.45	10.48	10.25
Residuals	4.59	4.45	3.71
Above 4 Products	8.91	8.88	8.60
Lube Oils	16.83	16.83	16.52
Crude	2.82	2.82	2.81

REFINERY YIELDS

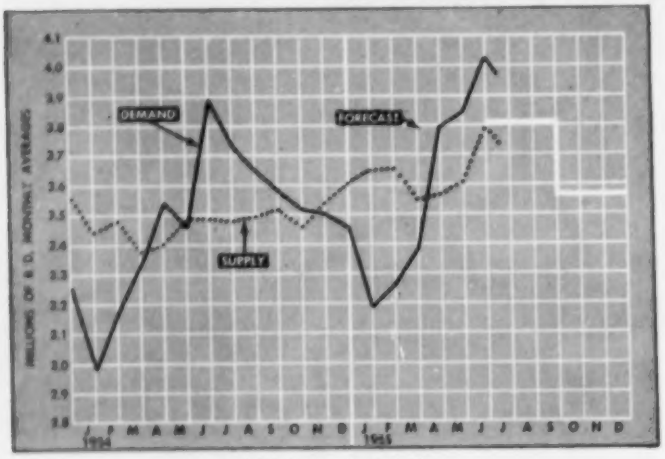
% on Crude Runs to Stills

	July 1955*	June 1955	July 1954
Gasoline	44.8	44.6	43.8
Kerosine	3.6	3.7	4.2
Distillate	21.3	21.8	20.2
Residuals	14.8	14.9	15.6

*Through July 15.

SOURCE OF DATA (except prices): May, June and July, API weekly reports; earlier months, Bureau of Mines

Gasoline Demand At All Time High

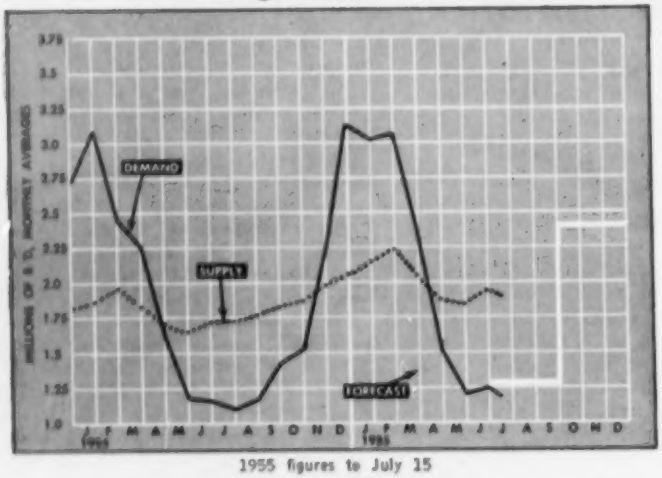


1955 figures to July 15

MOTOR FUELS

	From Crude	From Nat. Gas	Total
SUPPLY (Millions of b/d)			
June '55	3.350	.430	3.780
June '54	3.065	.418	3.483
Change	+.285	+.012	+.297
% Change	+9.3	+2.9	+8.5
DEMAND (including Exports) (Millions of b/d)			
June '55			4.075
June '54			3.894
Change			+.181
% Change			+4.6
TOTAL SUPPLY (Millions of bbls.)			
6 Mos. '55	578.489	76.444	654.933
6 Mos. '54	548.702	74.166	622.868
Change	+29.787	+2.278	+32.065
% Change	+5.4	+3.1	+5.1
TOTAL DEMAND (including Exports)(Millions of bbls.)			
6 Mos. '55			652.376
6 Mos. '54			615.477
Change			+36.899
% Change			+6.0

High Crude Runs Make Distillate Output Soar

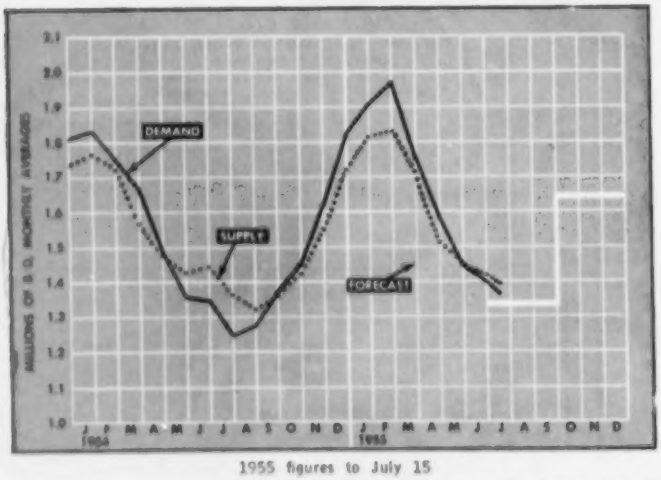


1955 figures to July 15

MIDDLE DISTILLATES

	Kerosine	Dist. Fuel Oil	Total
PRODUCTION (Millions of b/d)			
June '55	.279	1.640	1.919
June '54	.306	1.399	1.705
Change	−.027	+.241	+.214
% Change	−8.8	+17.2	+12.6
DEMAND (including Exports) (Millions of b/d)			
June '55	.148	1.063	1.211
June '54	.163	.996	1.159
Change	−.015	+.067	+.052
% Change	−9.2	+6.7	+4.5
TOTAL PRODUCTION (Millions of bbls.)			
6 Mos. '55	61.417	300.596	362.013
6 Mos. '54	62.763	259.649	322.412
Change	−1.346	+40.947	+39.601
% Change	−2.1	+15.8	+12.3
TOTAL DEMAND (including Exports)(Millions of bbls.)			
6 Mos. '55	59.112	308.259	367.371
6 Mos. '54	63.263	288.166	351.429
Change	−4.151	+20.093	+15.942
% Change	−6.6	+7.0	+4.5

Residual Demand Continues Strong



1955 figures to July 15

RESIDUAL FUELS

	Refinery Output	Imports	Total
SUPPLY (Millions of b/d)			
June '55	1.123	.296	1.419
June '54	1.123	.318	1.441
Change	−.0	−.022	−.022
% Change		−6.9	−1.5
DEMAND (including Exports) (Millions of b/d)			
June '55			1.398
June '54			1.349
Change			+.049
% Change			+3.6
TOTAL SUPPLY (Millions of bbls.)			
6 Mos. '55	211.284	81.315	292.599
6 Mos. '54	213.862	68.778	282.640
Change	−2.578	+12.537	+9.959
% Change	−1.2	+18.2	+3.5
TOTAL DEMAND (including Exports)(Millions of bbls.)			
6 Mos. '55			301.437
6 Mos. '54			284.635
Change			+16.802
% Change			+5.9

SOURCE OF DATA: May, June and July, API weekly reports; earlier months, Bureau of Mines

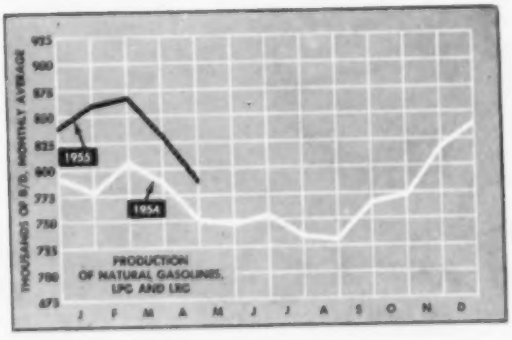
RUNS TO STILLS AND DISTRIBUTION OF PRIMARY STOCKS BY U.S. REFINERY DISTRICTS

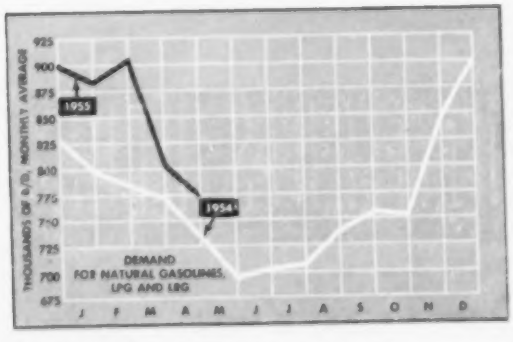
(Primary stocks include those at refineries, at large terminals and in pipelines; all data based on API reports)

District	RUNS TO STILLS (Millions of b/d average for week ending on date shown) July 15 1955	July 16 1954	Change	% Change	GASOLINE STOCKS (Millions of bbls. on date shown) July 15 1955	July 16 1954	Change	% Change	RESIDUAL STOCKS (Millions of bbls. on date shown) July 15 1955	July 16 1954	Change	% Change
East Coast	1.106	1.092	+ .014	+ 1.3	35.441	36.297	— .856	— 2.4	10.508	11.407	— .899	— 7.9
Gulf Coast	2.425	2.163	+ .262	+ 12.1	30.995	27.902	+3.093	+11.1	6.151	6.468	— .317	— 4.9
Total Coastal	3.531	3.255	+ .276	+ 8.5	66.436	64.199	+2.237	+ 3.5	16.659	17.875	— 1.216	— 6.8
Appalachian	.193	.188	+ .005	+ 2.7	6.545	6.921	— .376	— 5.4	.677	.859	— .182	—21.2
Ind.-Ill.-Ky.	1.451	1.294	+ .157	+ 12.1	33.893	36.428	—2.535	— 7.0	4.941	4.802	+ .139	+ 2.9
Okla.-Kans.-Mo.	.662	.627	+ .035	+ 5.6	14.883	16.591	—1.708	—10.3	1.106	1.321	— .215	—16.3
Other Inland	.644	.594	+ .050	+ 8.4	16.658	17.988	—1.330	— 7.4	2.158	2.344	— .186	— 7.9
Total Inland	2.950	2.703	+ .247	+ 9.1	71.979	77.928	—5.949	— 7.6	8.882	9.326	— .444	— 4.8
Total East of Calif.	6.481	5.958	+ .523	+ 8.8	138.415	142.127	—3.712	— 2.6	25.541	27.201	— 1.660	— 6.1
California	1.101	1.011	+ .090	+ 8.9	20.407	19.659	+ .748	+ 3.8	19.941	26.154	— 6.213	—23.8
Total U. S.	7.582	6.969	+ .613	+ 8.8	158.822	161.786	—2.964	— 1.8	45.482	53.355	— 7.873	—14.8

District	DISTILLATE FUEL OIL STOCKS (Millions of bbls. on date shown) July 15 1955	July 16 1954	Change	% Change	KEROSINE STOCKS (Millions of bbls. on date shown) July 15 1955	July 16 1954	Change	% Change	TOTAL MIDDLE DISTILLATE STOCKS (Millions of bbls. on date shown) July 15 1955	July 16 1954	Change	% Change
East Coast	35.899	31.346	+ 4.553	+14.5	12.469	12.722	— .253	— 2.0	48.368	44.068	+ 4.300	+ 9.8
Gulf Coast	19.103	15.141	+ 3.962	+26.2	6.221	5.879	+ .342	+ 5.8	25.324	21.020	+ 4.304	+20.5
Total Coastal	55.002	46.487	+ 8.515	+18.3	18.690	18.601	+ .089	+ 0.5	73.692	65.088	+ 8.604	+13.2
Appalachian	3.374	2.219	+ 1.155	+52.1	1.008	.962	+ .046	+ 4.8	4.382	3.181	+ 1.201	+37.8
Ind.-Ill.-Ky.	21.170	18.870	+ 2.300	+12.2	7.608	6.962	+ .646	+ 9.3	28.778	25.832	+ 2.946	+11.4
Okla.-Kans.-Mo.	12.096	10.113	+ 1.983	+19.6	1.970	1.783	+ .187	+10.5	14.066	11.896	+ 2.170	+18.2
Other Inland	6.655	5.080	+ 1.575	+31.0	1.785	1.572	+ .213	+13.5	8.440	6.652	+ 1.788	+26.9
Total Inland	43.295	36.282	+ 7.013	+19.3	12.371	11.279	+1.092	+ 9.7	55.666	47.561	+ 8.105	+17.0
Total East of Calif.	98.297	82.769	+15.528	+18.8	31.061	29.880	+1.181	+ 4.0	129.358	112.649	+16.709	+14.8
California	10.635	12.025	— 1.390	+11.6	320	438	— .118	—26.9	10.955	12.463	— 1.508	—12.1
Total U. S.	108.932	94.794	+14.138	+14.9	31.381	30.318	+1.063	+ 3.5	140.313	125.112	+15.201	+12.1

Natural Gas and Refinery Gas Liquids





SUPPLY AND DEMAND STATISTICS

Bureau of Mines Data

CURRENT PRODUCTION (1000 b/d monthly average)	Apr. 1955	Mar. 1955	Apr. 1954
At Natural Gasoline and Cycling Plants			
Liquefied Petroleum Gas	333	361	313
Natural Gasoline and Isopentane	272	275	263
Condensate	17	21	31
Finished Gasoline, Naphtha and other	63	63	54
Total Natural Gasoline and Cycling Plant Production	685	720	661
Liquefied Refinery Gases	108	111	89
Total Marketable Gas Liquids	793	831	750
Lease Condensate	112	114	105
Total Natural Gas Liquids	905	945	855
CURRENT DEMAND (1000 b/d monthly average)			
LPG and LRG	417	452	380
Natural Gasoline, Isopentane and Other	358	349	358
Total Marketable Gas Liquids	775	801	738

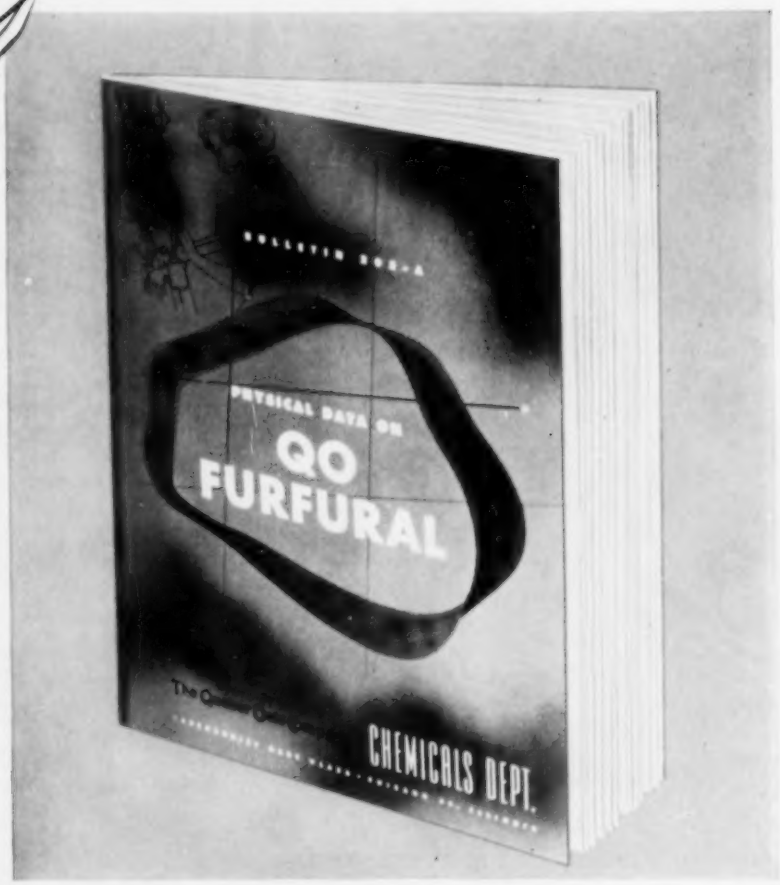
CUMULATIVE PRODUCTION	Apr. 1955	Apr. 1954
LPG and LRG	57,600	52,245
Natural Gasoline, Isopentane and Other	42,913	41,390
Total Marketable Gas Liquids	100,513	93,635
CUMULATIVE DEMAND (1000 bbls.)		
LPG and LRG	58,498	50,780
Natural Gasoline, Isopentane and Other	42,395	41,749
Total Marketable Gas Liquids	100,893	92,529

STOCKS (1000 bbls., end of month)	Apr. 1955	Mar. 1955	Apr. 1954
LPG and LRG	6,859	6,122	5,942
Natural Gasoline, Isopentane and Other	5,176	5,365	4,529
Total Stocks	12,035	11,487	10,471

write for:

NEW QUAKER OATS' BULLETIN 203-A

physical data on QO® FURFURAL



This bulletin—just published—includes graphs and tables of the physical properties of QO Furfural. In addition, the recovery of furfural for re-use in continuous processing is described.

To help you evaluate QO Furfural as a selective solvent for lubricating oils, gas oil, catalytic cracker recycle stock, butadiene and other processes, write for your copy of 203-A.

The Quaker Oats Company — **CHEMICALS DEPT.**

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Room 539W, 120 Wall St., New York 5, N. Y.
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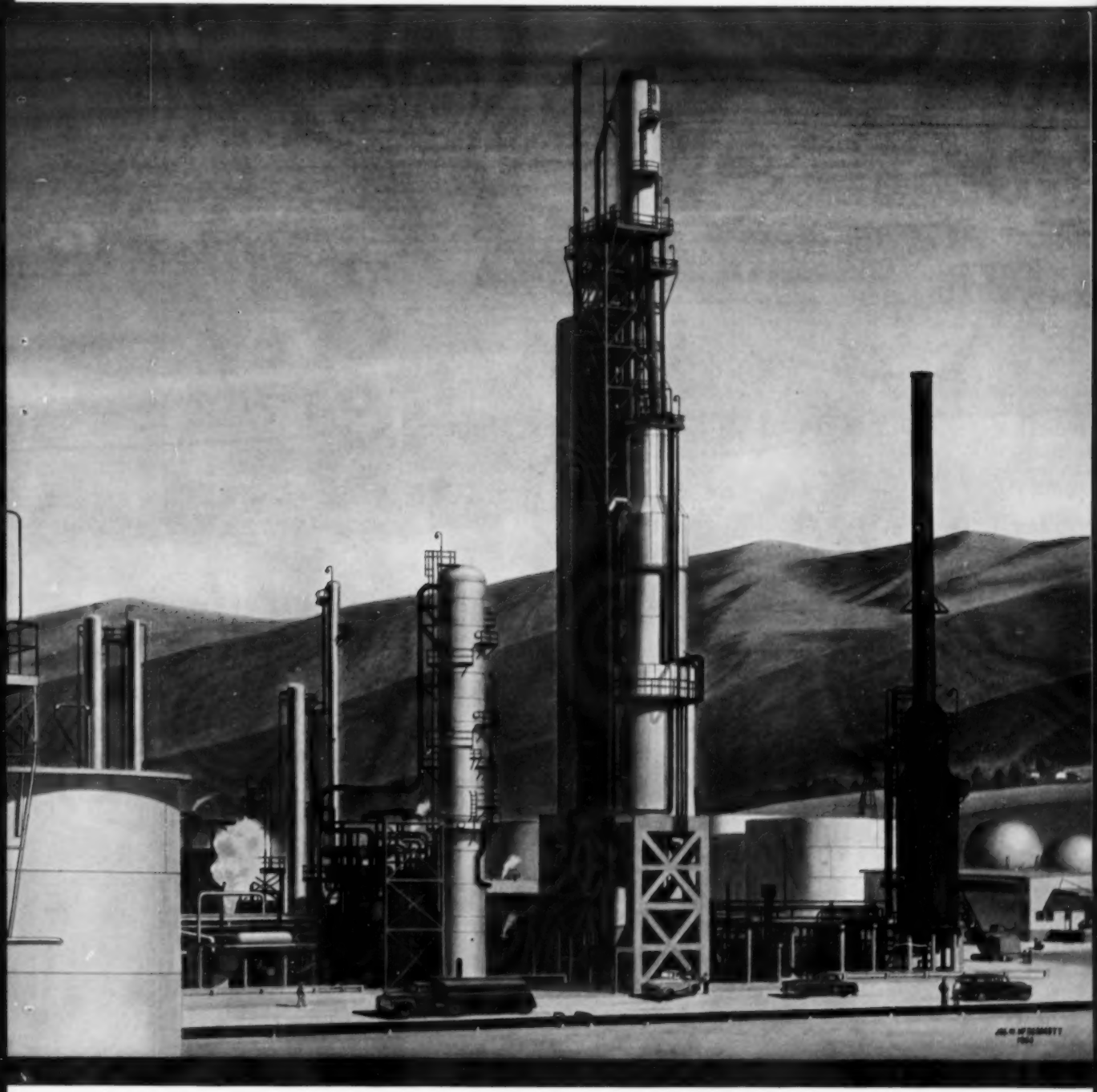
(To obtain more data on advertised products see page 1252)



SALT LAKE REFINERY

The Houdriflow Catalytic Cracking Unit of the Salt Lake Refining Company has been consistently handling charge rates well above the 13,000 BPSD design reactor charge rate since going on stream in 1950. In 1952 this installation served as a test unit for studies in catalyst travel. Radioactive beads were introduced into the reactor, and their subsequent movements were checked by Geiger counters. These tests proved that the catalyst circulated through all parts of the Houdriflow unit with excellent uniformity.

Houdriflow units are now operating at the highest conversion levels ever achieved in the industry. An informative new brochure describing the Houdriflow process is available on request. Write to: Houdry Process Corporation, 1528 Walnut Street, Philadelphia 2, Pa.

HOUDRY

PROCESS CORPORATION

Pioneer in Catalytic Processes

GOING PLACES *underground with Cities Service...*

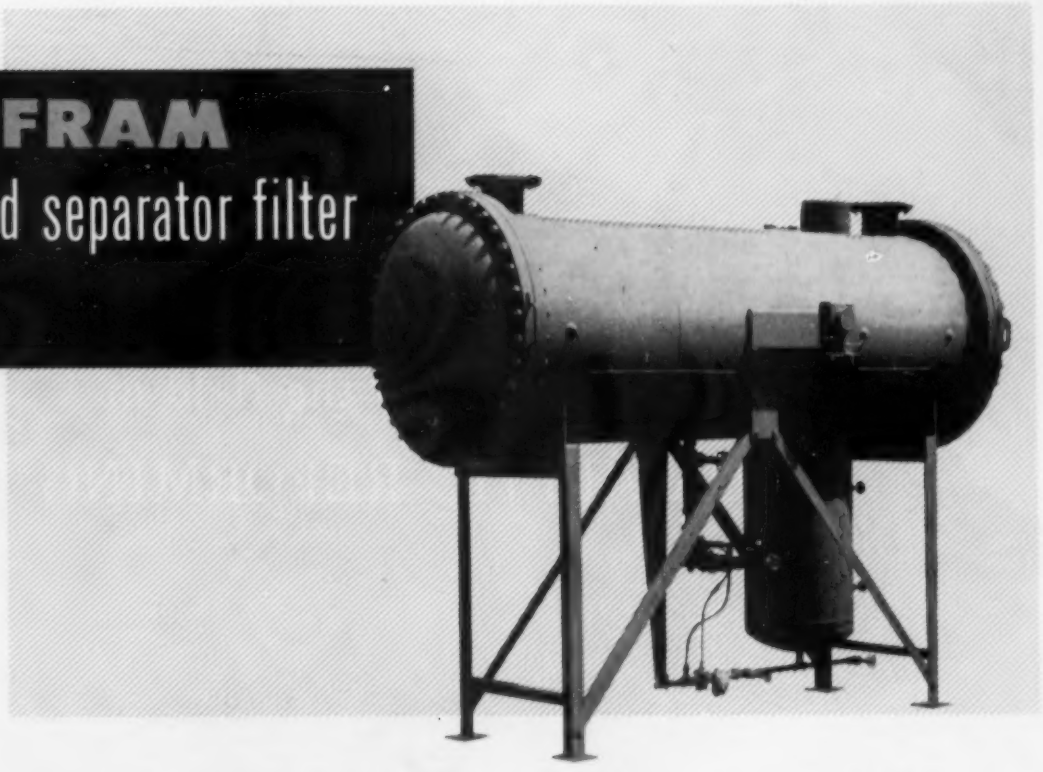
Cities Service transported more oil through more miles of pipeline in 1954 than ever before in Company history. Reason for this bustling underground activity—more Cities Service customers than ever before in Company history!

CITIES SERVICE

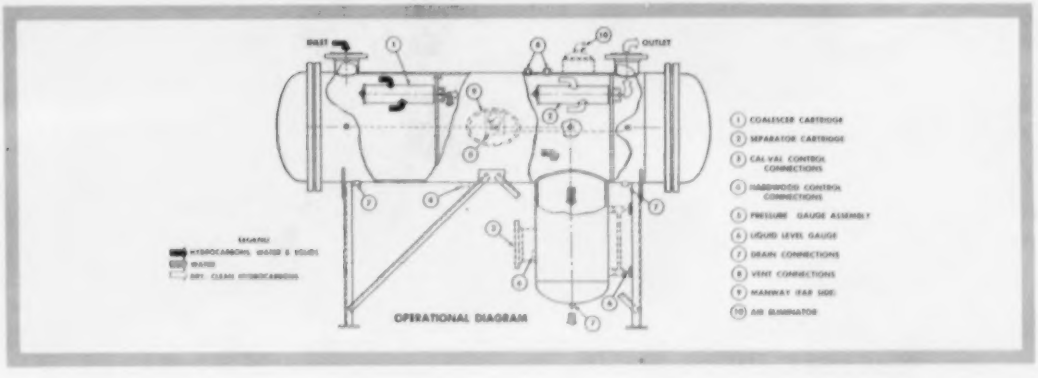
A Growth Company

Number 11 of a series

FRAM
liquid separator filter



Removes the water cloud and solids from light petroleum products.



Here is the sure way to obtain clean, water-free petroleum products — the FRAM Liquid Separator/Filter is designed for use in refinery process streams and petroleum marketing installations to remove entrained water and solids (down to 5 microns) from gasoline, jet fuel, diesel fuel, kerosene, burning oils. Capacity is from 5 to 1000 GPM. Built to API-ASME Code. Send for Bulletin.

WARNER LEWIS COMPANY

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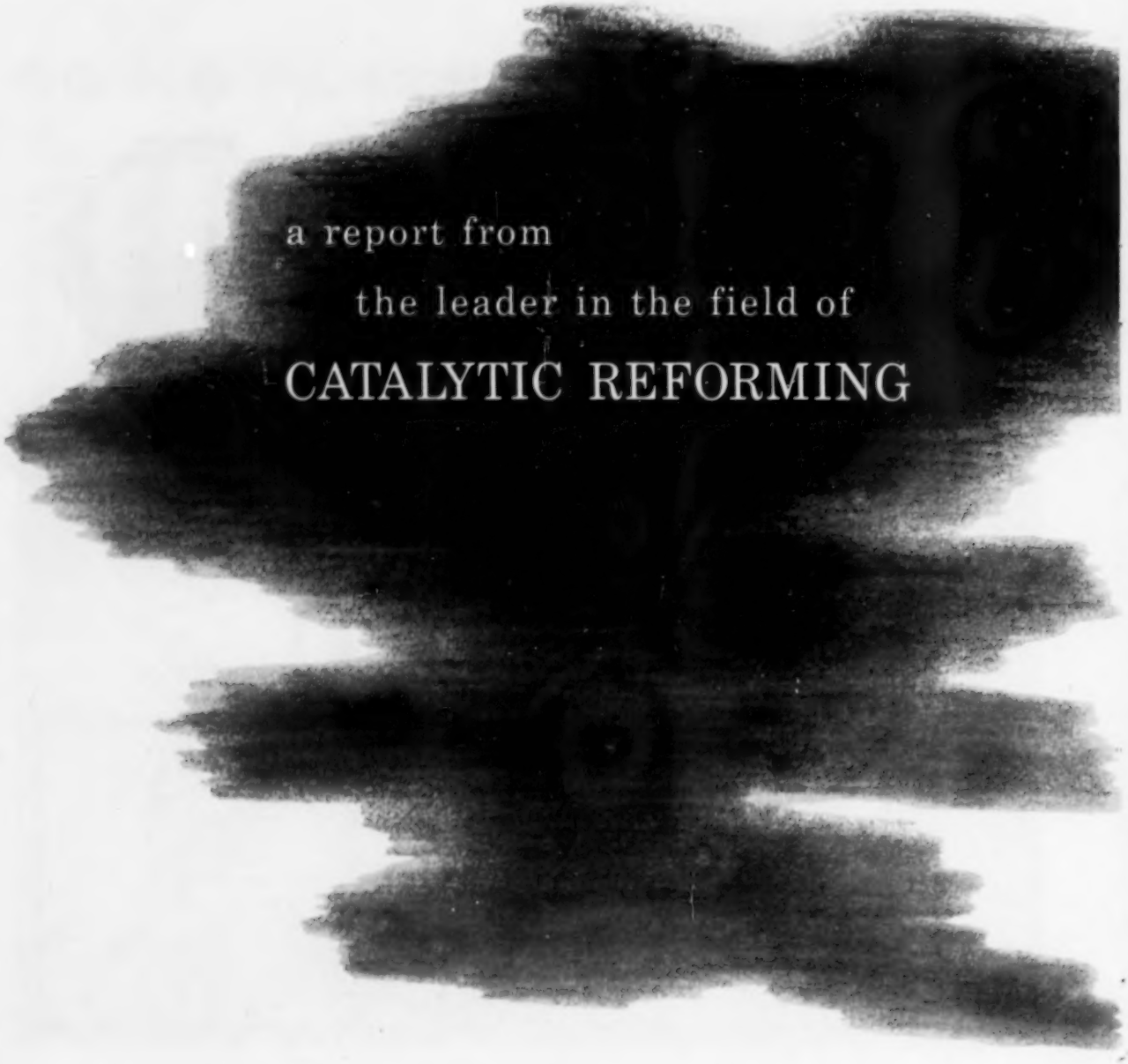
DIVISION OF FRAM CORPORATION


a report from
the leader in the field of
CATALYTIC REFORMING

MUCH HAS TRANSPIRED since Universal Oil Products Company announced in March, 1949, the availability of Platforming—the catalytic reforming process which pioneered the use of a platinum catalyst and which established catalytic reforming as one of the basic refining processes. Just seven months after this announcement, the first commercial unit was placed on stream. Since that time the process has received an unsurpassed acceptance throughout the world's petroleum refining industry.

The unprecendented recognition given to this catalytic reforming process is indicative of how well it has fulfilled the industry's need for an economical and efficient method to up-grade low-quality napthas. Platforming's adaptability is brought out in the sizes of the units which have been installed. With capacities ranging from 500 to 29,000 barrels, the UOP Platforming process has proved to be an answer to refiners' octane problems, no matter what the scope of their operations might be.

Recognizing that the ever-increasing demands for higher octanes would place additional burdens on the petroleum refining industry, Universal continued its studies in catalytic reforming. The results of this work were announced last March, with the introduction of Rexforming.

This newest catalytic reforming process will permit refiners to produce fuels of any useful octane rating, without limitations due to feed stocks. Laboratory and pilot plant tests have shown Rexforming to be capable of producing gasolines in excess of 100 clear octane.

Commercial acceptance of Rexforming has been immediate. Units are now being engineered and construction on these installations is scheduled to begin shortly.

The future for catalytic reforming is certainly one of continued growth and progress. It is a future in which Universal Oil Products Company will play a leading role.

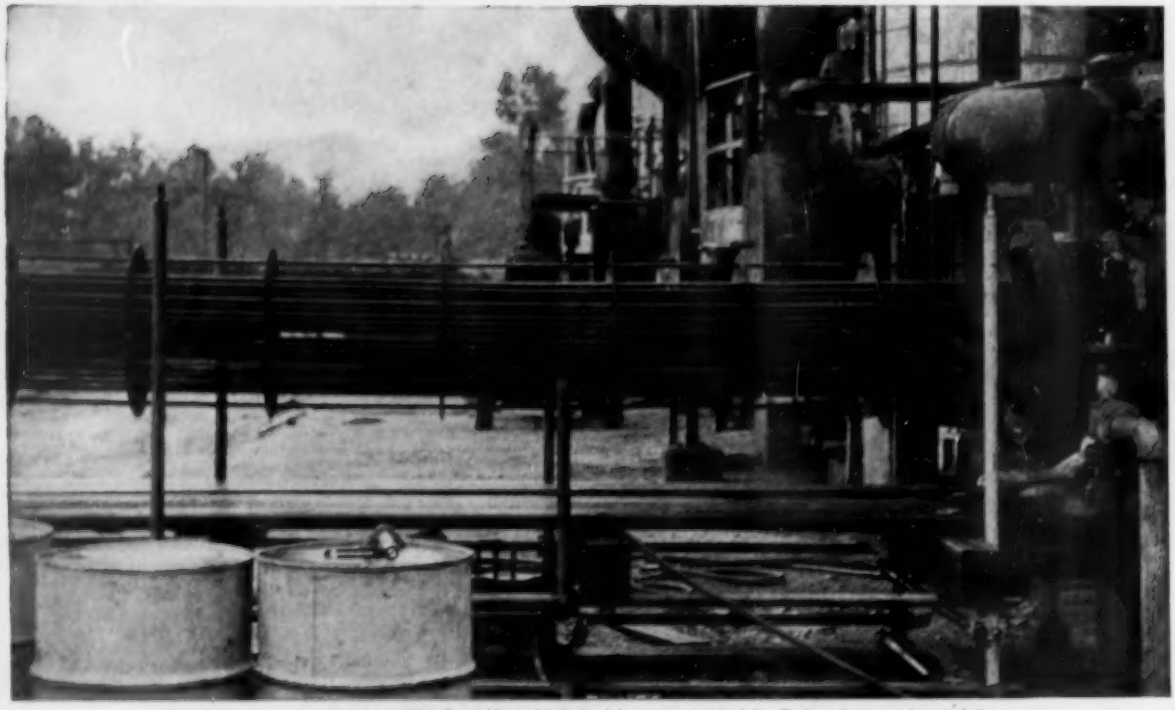
UNIVERSAL OIL PRODUCTS COMPANY

UOP

30 ALGONQUIN ROAD,
DES PLAINES, ILL., U. S. A.

Universal Service Protects Your Investment

 (To obtain more data on advertised products see page 1252)



READY FOR INSPECTION—This bundle, which had been protected by Polyrad corrosion inhibitor, was pulled for inspection as part of the regular maintenance program.

QUICK TURN-AROUND

Turn-around Time no longer need be headache time—not when Polyrad costs so little.

An average treatment is about 1 quart of Polyrad corrosion inhibitor per 1,000 barrels of fluid. That's all it takes to prevent excessive down time for cleaning or replacing fouled and corroded refinery equipment.

Polyrad's detergent action is so powerful that in many cases fouled equipment can be cleaned up while in operation. Organic and inorganic deposits don't have a chance to collect in Polyrad-protected equipment. They are quickly loosened and removed in the fluid stream. That's why all around the refinery, Polyrad helps maintain throughput, increases heat transfer, and cuts down time for maintenance.

Stocks of Polyrad are maintained throughout the country. A Hercules technical representative will be glad to discuss its application to your specific operating conditions.

NO NEED TO REPLACE—Polyrad corrosion inhibitor had done its job well, as this close-up shows. Still clean and free of corrosion, the bundle was returned to service immediately.

Pine Chemicals Division,
Naval Stores Department
HERCULES POWDER COMPANY
INCORPORATED
984 King Street, Wilmington 99, Del.

POLYRAD®
FILMING AMINE INHIBITOR

NA55-3

SINCLAIR OIL CORPORATION

says

OK

in print

Thriftiest Boiler
in the business
ANOTHER SINCLAIR FIRST!
SINCLAIR OIL CORPORATION • 600 FIFTH AVENUE • NEW YORK 20, N. Y.
SINCLAIR

Sinclair Oil Corporation pioneered a new boiler to secure greater efficiency in refinery operation. This advertisement from the Oct. 16, 1954 Business Week emphasizes the results obtained with this unit.

This B&W Carbon Monoxide Boiler, installed to absorb the heat from the exhaust gas stream of Sinclair's new Houston fluid cracking unit, was the first of its kind to go into refinery service. Here are the operating results:

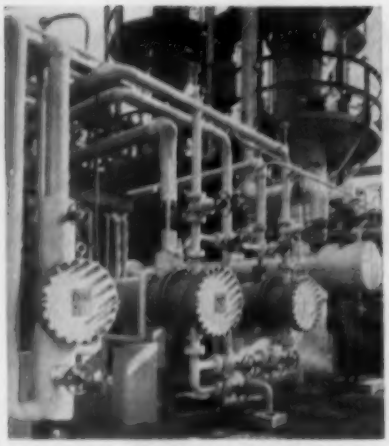
Gas weight to boiler—lb per hr	650,000
Gas temperature to boiler—	990
Per cent CO in gas stream to boiler—, % by volume	4.8
Steam from sensible heat and combustible in cracking unit exhaust gas—lb per hr	220,000
Total steam capacity, boiler and economizer—lb per hr	330,000
Btu saved from cracking unit gas stream—Btu per hour	218,000,000

The Babcock & Wilcox Company, Boiler Division
161 East 42nd Street, New York 17, N. Y.

BABCOCK & WILCOX

BOILER DIVISION

G-700



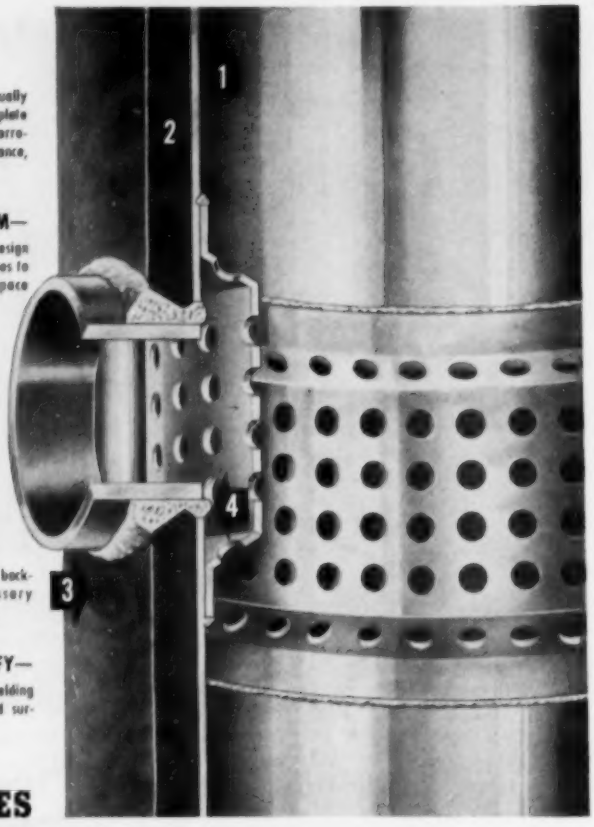
Stainless-clad steel checks corrosion in these acid stripping and cooling units handling naphthenic acid at 350° F.

1 ECONOMY—
High alloy layer—usually 10% or 20% of total plate thickness — assures corrosion and abrasion resistance, long equipment life.

2 DESIGN FREEDOM—
Integral bond allows design and fabrication of shapes to meet process and space needs.

3 STRUCTURAL STABILITY—
Low-cost carbon steel backing provides necessary strength and rigidity.

4 EASY TO MODIFY—
Normal cutting and welding will not endanger clad surface or bond.



CLAD STEEL EQUIPMENT ASSURES

LONG LIFE AND EASY MODIFICATION

To help you lengthen profitable service life *and* overcome the factor of high first cost, clad steel equipment offers two unique advantages. First, clad steel construction permits easy tank and pressure vessel revision when new openings must be cut and flanges or pipes welded on. The bond between cladding and backing is not affected by the temperature range where clad can be applied. This eliminates seepage and crevice corrosion.

Second, you get all the benefits of solid high alloy's corrosion resistance and protection with savings up to 50% in material costs. Because cladding and backing are bonded over their entire surface, the API-ASME Code permits full gage consideration for design purposes.

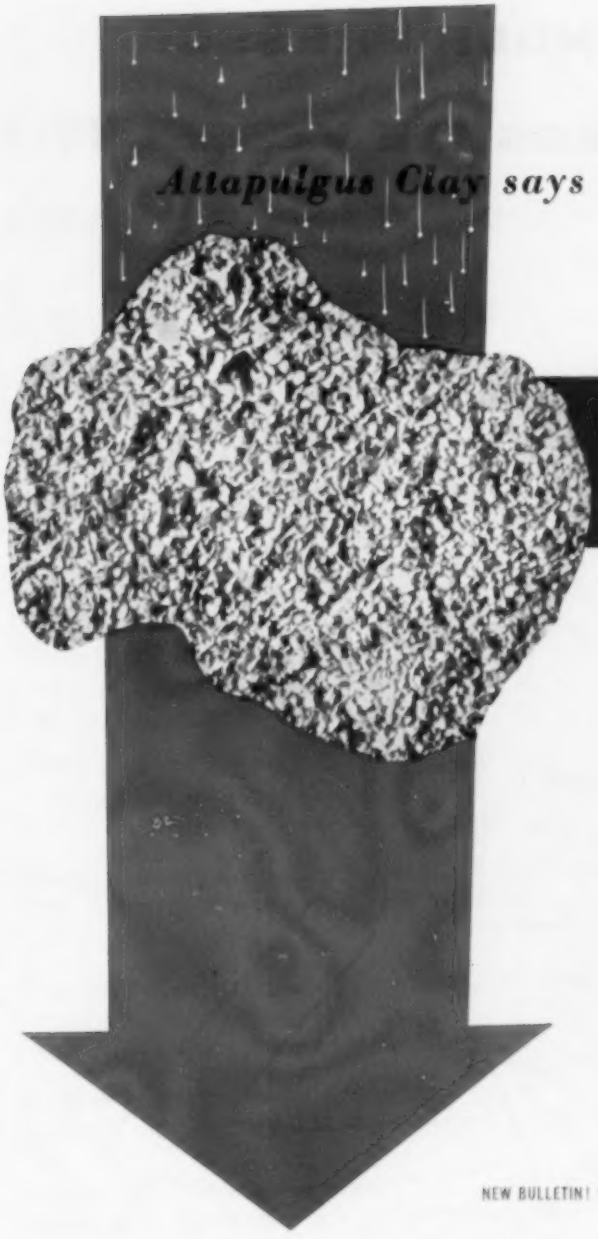
Long service life and low cost protection, plus other advantages such as economical field erection and easier drainage, cleaning and inspection, can be obtained from 16 cladding materials. *Qualified* equipment builders know best how to apply these to your new processing equipment. By working with your own engineers and consultants from the start, they can help you get longer equipment life at lower cost. Lukens offers the widest available selection of clad steels—stainless, nickel, Inconel, Monel, copper—and cooperates with fabricators in helping you to select the type best suited to your needs. If you would like more information, consult one of your builders or write Manager, Marketing Service, Lukens Steel Co., 752 Lukens Building, Coatesville, Pa.

LUKENS CLAD STEELS

STAINLESS-CLAD · NICKEL-CLAD · INCONEL-CLAD · MONEL-CLAD

PRODUCER OF THE WIDEST RANGE OF TYPES AND SIZES OF CLAD STEEL PLATES AND HEADS AVAILABLE

(To obtain more data on advertised products see page 1252)



Attapulgus Clay says **STOP!**

to
Platinum Catalyst
poisons

Attapulgus Clay keeps strict watch over your catalytic reforming feed stocks, protects you against losses caused by catalyst poisoning. It does this by effectively reducing the detrimental constituents that temporarily (sometimes permanently) foul the catalyst.

Here are the troublemakers (some need only be present at 10 parts per billion) that Attapulgus Clay adsorbs from the stream: ARSENIC—either present in the crude, or picked up from corroding tubes and equipment; LEAD—either crude-occurring or picked up; SULFUR—alkyl or aryl; NITROGEN—known to exist in some crudes, but whose source usually is in amine-type corrosion inhibitors.

Setting up this effective clay treatment safeguard can be accomplished at a surprisingly low investment—one that pays out promptly in terms of the most favorable production rate.

This is another solid example of how M&C products keep growing in value to refiners. There's always a *new place* for these versatile minerals to improve the quality and cut the processing costs of petroleum products.

NEW BULLETIN! "Preparation of Petroleum Feeds for Platinum Catalysts"

is just off press. Check the coupon for prompt mailing of your personal copy, and for other assistance, if desired.

ATTAPULGUS **ATTAPULGUS PRODUCTS** *from*

MINERALS & CHEMICALS CORPORATION OF AMERICA
210 W. WASHINGTON SQUARE, PHILADELPHIA 5, PA.

ALWAYS A BETTER WAY . .

MINERALS & CHEMICALS CORPORATION OF AMERICA
Dept. D, 210 W. Washington Square, Philadelphia 5, Pa.

☐ Please send me "Preparation of Petroleum Feeds For Platinum Catalysts"

☐ I'd like to talk to a representative about a specific feed stock problem.

name _____ title _____

company _____

address _____

city _____ zone _____ state _____

WHEN YOU'RE UNDER PRESSURE

ON PRESSURE VESSELS . . .

THIS IS THE KIND OF HELP YOU GET AT KELLOGG . . .

Design Engineering: Kellogg will assume entire responsibility or work closely with your own design engineers on their proposals. Optimum designs are assured either way.

Technical Competence: Kellogg's experience in metallurgy, heat transfer, stress analysis, metal fatigue, corrosion control, is unequalled among pressure vessel fabricators.

Fabricating Techniques: Kellogg fabrication methods are the culmination of 40 years of building pressure vessels to exacting specifications. Many improved techniques have resulted, such as K-Weld*.

Non-Destructive Testing: Kellogg's complete facilities include the company's portable "atomic cameras" which can photograph welded seams up to six inches thick in a single short exposure.

Prompt Delivery: Kellogg's plant modernization program assures faster delivery than ever before. Small and large orders receive the same attention.

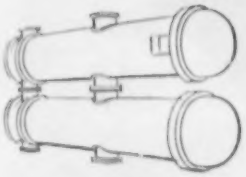
Construction Service: Kellogg's continuing work in erecting vessels for complete oil refineries, pulp mills, and chemical plants provides a fully-staffed construction department with crews that know their jobs.

Guaranteed Performance: Kellogg's reputation has been built on long and efficient product life. The MWK name plate is your guarantee.

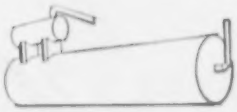
FABRICATED PRODUCTS DIVISION
THE M. W. KELLOGG COMPANY, 225 BROADWAY, NEW YORK 7, N. Y.
In Canada: The Canadian Kellogg Company, Limited, Toronto
In Europe: Kellogg International Corporation, London
SUBSIDIARIES OF PULLMAN INCORPORATED

*Trademark of The M. W. Kellogg Company

PUT YOUR PROBLEMS UP TO M KELLOGG W



HEAT TRANSFER EQUIPMENT



TANKS AND REACTORS

KNOCKDOWN VESSELS

PROCESS PIPING

PRESSURE VESSELS

(To obtain more data on advertised products see page 1252)

There's a faster, safer, cheaper, more accurate way to measure tanks with... a new

Gilbarco

ELECTRONIC TANK GAUGE

A crew of hand gaugers can climb slippery steel stairways in icy cold to lower tapes through opened manholes. Or one man can sit in a gauge house before a Gilbarco Remote Receiver and gauge tanks at the rate of fifty an hour—with a degree of accuracy never approached by *any* other method. Here is *automation* in tank gauging. For illustrated booklets and full information about this great new advance in liquid level measurement, write . . .

GILBERT & BARKER MANUFACTURING COMPANY, WEST SPRINGFIELD, MASSACHUSETTS

Is A Control Valve Always A Control Valve?

Yes . . . but not necessarily a conventional control valve. The Conoflow EB Current Controller—a unique final control element—is an electric valve which controls *at the source* rather than in the line. This is the perfect solution for handling extremely viscous flows or when corrosion or abrasion presents a tough problem. In many services too, it offers a more economical approach to fluid control than by means of a conventional control valve.

The Cono EB Current Controller is essentially a pneumatic-electric transducer. It consists of the proved Conoflow Cylinder Conomotor and an electrical component such as a rheostat, potentiometer or autotransformer. The Cylinder, operating from a 3-15 psi air signal, produces precisely regulated rotary motion (to 360°) of the electrical component to control voltage, current, inductance, capacitance, resistance or other electrical values.

A widely used method of regulating fluid flow with an EB unit is to position a rheostat in the motor field or armature circuit as a direct function of the pneumatic signal pressure. On many applications, electronic speed changers and electric motors can be controlled from zero to full capacity, offering a resultant control range that cannot be matched by conventional control valves.

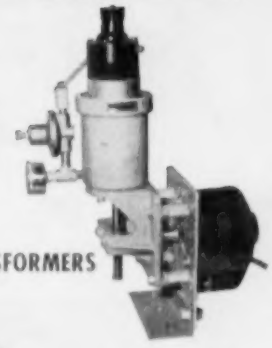
Conoflow EB Current Controllers are available in over 200 combinations of electrical components to handle a wide variety of applications. A few are suggested here:

Constant Pressure	Constant Temperature
Proportional Flow	Boiler Feed Water Control
Liquid Level	Rewind Control
Machine Tool Speed	Constant Flow
Conveyor Control	Stoker Feed Control
Heat Treating	Humidity Control

The Conoflow EB Current Controller provides automatic feedback control with these electronic speed changers:

Louis Allis—*Select-A-Spede*	Reliance—*V.S. Drive*
Brown-Brockmeyer—*Dial-A-Speed*	Servo-Tek Products—*Servo-Tek*
General Electric—*Thy-Mo-Trol*	Weltronic—*Vara-Speed*
Master Electric—*Speedranger*	Westinghouse—*Mot-O-Trol*

WRITE TODAY FOR BULLETIN EB-1. Tell us something of your process control problem. Chances are we can suggest from direct experience an installation that would be profitable to you. No obligation, of course.



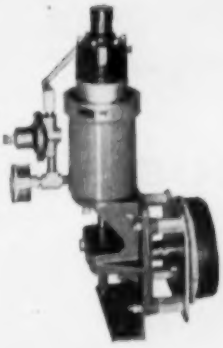
General Radio (Variac)

AUTOTRANSFORMERS

Superior Electric (Powerstat)

RHEOSTATS

Cutler Hammer
General Electric
Ohmite
Ward Leonard
Westinghouse

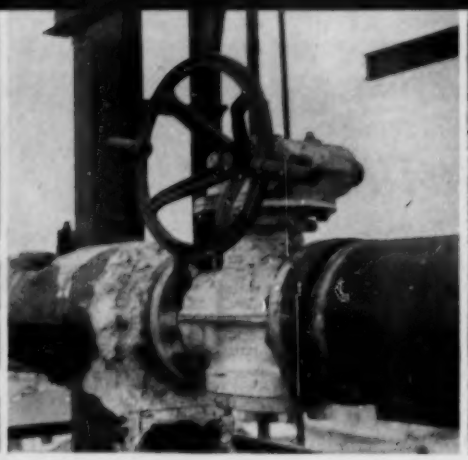


POTENTIOMETERS

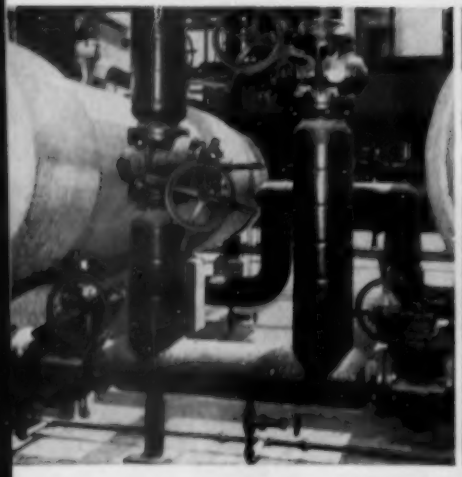
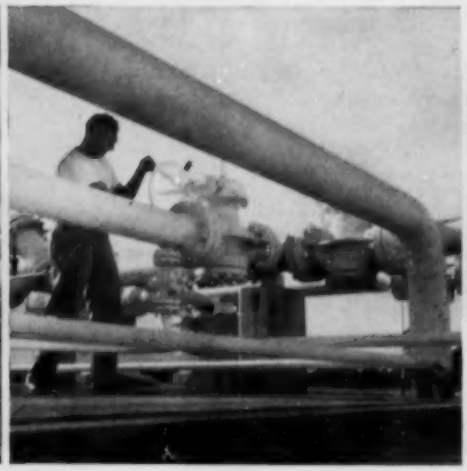
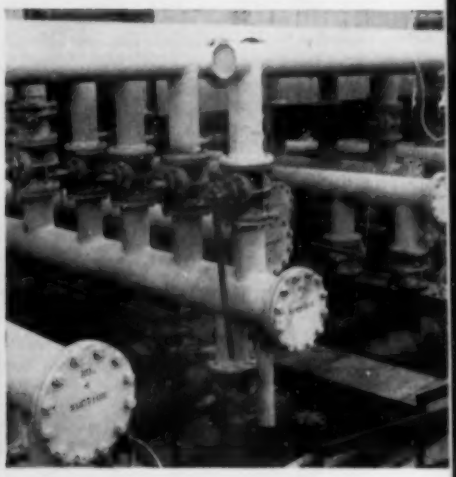
Allen-Bradley
Clarostat
Fairchild
Helipot
Mallory

CONOFLOW CORPORATION
FOREMOST MANUFACTURERS OF FINAL CONTROL ELEMENTS
2100 ARCH STREET, PHILADELPHIA 3, PA.

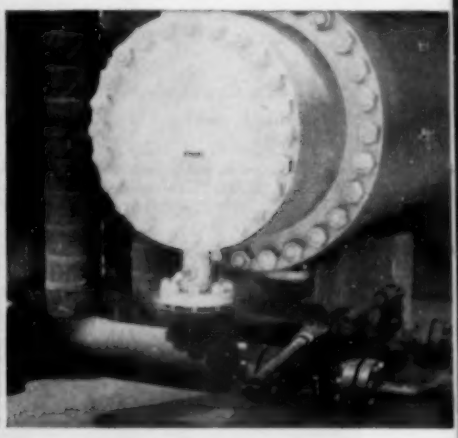
Cono-Trols®



Positive, fast, leakproof flow control

costs less per year when you specify

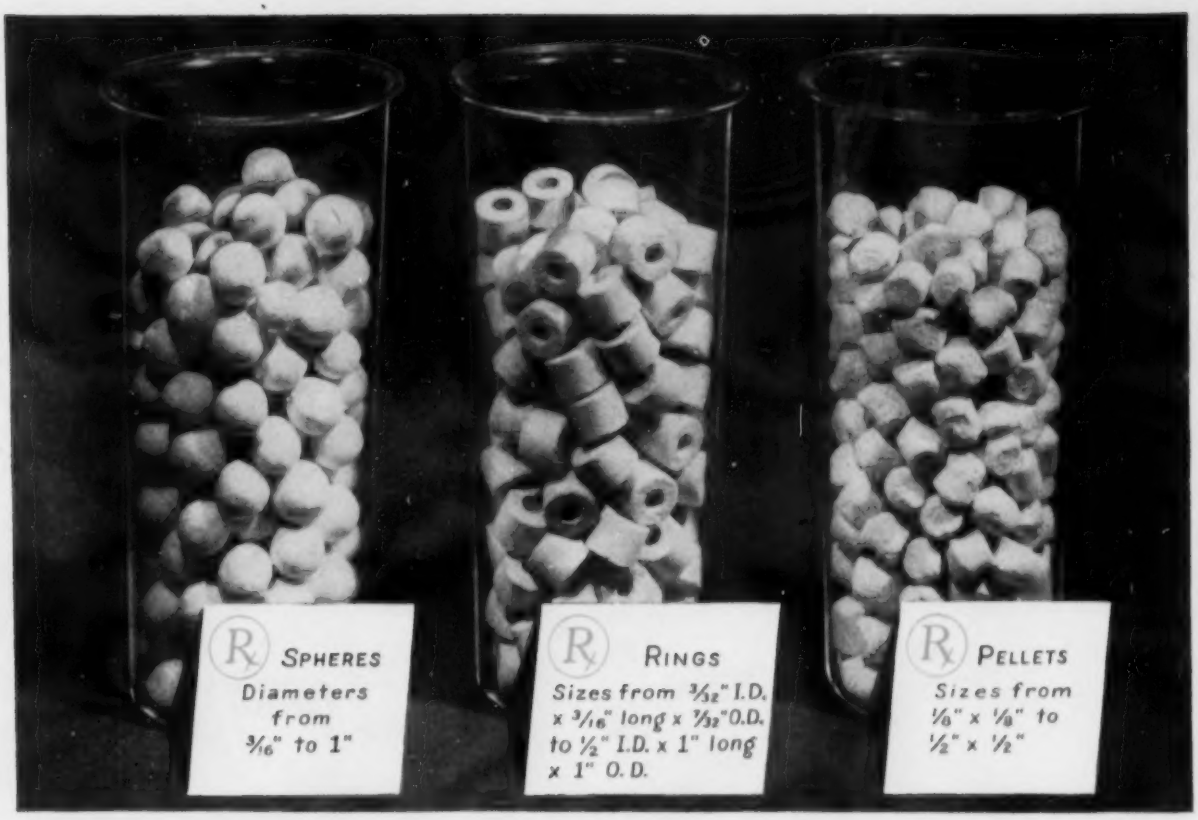


ROCKWELL-Nordstrom VALVES

LUBRICANT SEALED FOR POSITIVE SHUT-OFF

Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee Peacock Brothers Limited


℞ SPHERES
Diameters from 3/16" to 1"
℞ RINGS
Sizes from 3/32" I.D. x 3/16" long x 7/32" O.D. to 1/2" I.D. x 1" long x 1" O.D.
℞ PELLETS
Sizes from 1/8" x 1/8" to 1/2" x 1/2"

What are your catalyst carrier applications?

Norton engineered and prescribed carriers offer you important processing advantages

What do you need? An inert, high alumina carrier for fixed bed oxidation reactions — such as those involved in the manufacture of phthalic anhydride, maleic anhydride and ethylene oxide?

An inert, low density carrier for use as a space filler or tower packing?

Norton ALUNDUM* fused alpha alumina carriers are proving highly successful in such processes. Containing 77% to 89% alumina, they are outstanding for chemical stability and resistance to abrasion and erosion — and their low density is a valuable quality in packing and filling applications.

ALUNDUM carriers are commercially available in the form of spheres, rings and pellets. Also available in experimental quantities are carriers made of MAGNORITE*, CRYSTOLON*, Fused Stabilized Zirconia and Kyanite materials.

ALUNDUM Spherical Carriers

provide uniform beds in catalytic converters, reducing channeling and pressure drop to a minimum. Medium porosity spheres (40%-44%) have a network of open pores on the outside surface only. These are specifically recommended for applications where the carrier is coated with a catalyst. High porosity spheres (45%-49%) have an internal as well as external network of pores, and are suitable for applications where the carrier is impregnated with a catalyst.

Other Norton Refractories

for chemical processing include porous mediums, laboratory ware, ALUNDUM, MAGNORITE, CRYSTOLON, and Fused Stabilized Zirconia shapes. All are *engineered and prescribed* to give you the best possible ℞ — the most effective combination of physical characteristics plus thermal, chemical and electrical properties. For details call in your Norton Refractories Engineer, or write, mentioning your specific requirements to NORTON COMPANY, 287 New Bond St., Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Canada.

NORTON

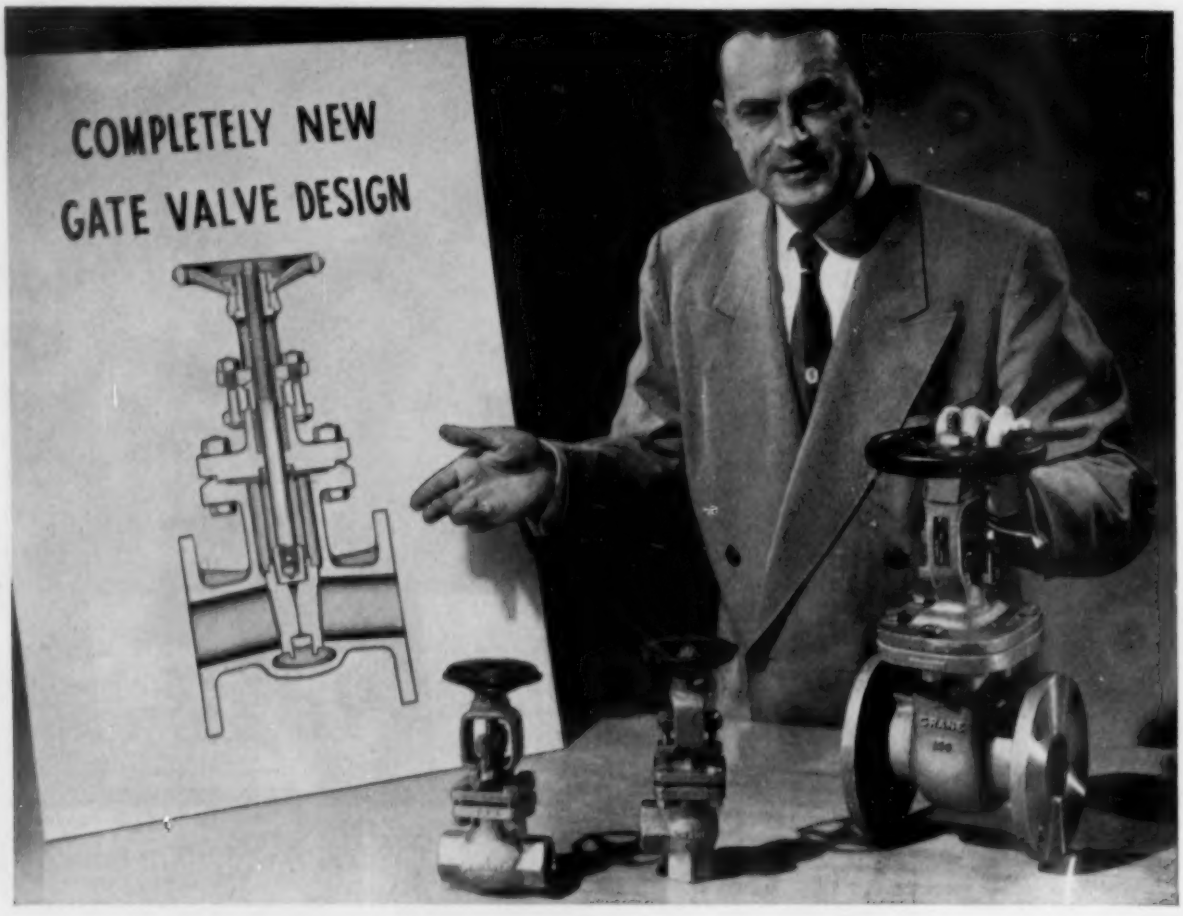
REFRACTORIES

Engineered... ℞ ... Prescribed

Making better products... to make your products better

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

(To obtain more data on advertised products see page 1252)



New CRANE Corrosion-resistant valves in 18-8 SMo and Craneloy 20

Gate, Globe, Angle and Check Patterns

Few valves for process industries have ever received the quality treatment given this new Crane line—at prices you'll find O.K.

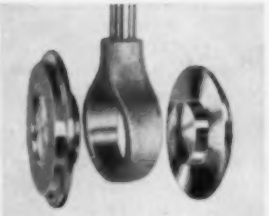
Note, for instance, the unique yet simple split-wedge disc construction in the gate valves. Those dual identical discs are free to rotate in their holder—the most effective design for resisting galling. The trunnion shape at the back of each disc assures even distribution of closing forces. You couldn't buckle them if you tried.

The globe and angle valves give equally outstanding control of corrosive fluids. A new type disc-stem connection, with minimum clearances, practically eliminates vibration. By placing seating load closer to seats, it provides easier, more accurate closure.

Check valves feature compact, thoroughly proved, non-slamming design.

Throughout, these valves are built for better service in your choice of Crane 18-8 SMo Stainless Steel or Craneloy 20. Both lines come with screwed or flanged ends.

ASK FOR THIS CATALOG—Full information including service suggestions given in circular AD-2080—available from your Crane Representative or by mail. Crane Co., General Offices: Chicago 5, Ill. Branches and Wholesalers everywhere.



New split-wedge disc in gate valves combines the benefits of free rotation with uniform seat load pressure.

for the THRIFTY BUYER

CRANE CO.

VALVES · FITTINGS · PIPE
KITCHENS · PLUMBING · HEATING

CRANE'S FIRST CENTURY...1855-1955

When "dream cars" come true

Barium-Based Additives Will Still Fortify Their Lube Oils

Now representing 75% of all detergent additives, barium-based additives are getting better all the time. And so are barium compounds used to make them.

We should know. For we are the principal supplier of barium chemicals to additive producers . . . and have been hard at work these many years to keep one step ahead of their needs.

For instance: we increased output 100% in the past 2 years and continue to look to the future. We pioneered production of dense, crystalline electric-furnace barium oxide and are now piloting an advanced process developed by Westvaco engineers. Though we had an ample reserve of high-grade barytes, we recently acquired another large mineral deposit to further increase ore reserves against anticipated end-use growth.

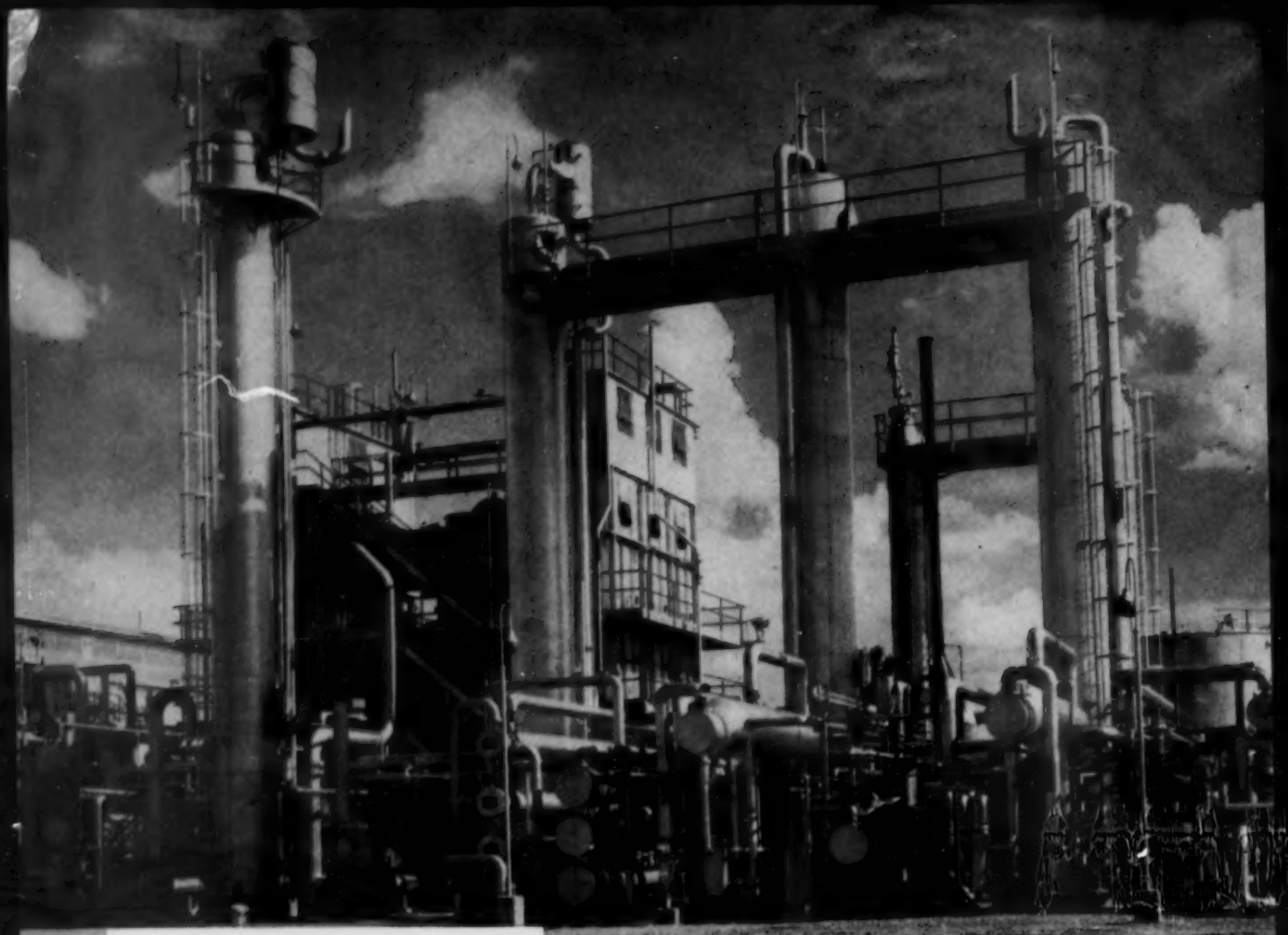
Yes, when "dream cars" come true, better additives for better lube oils will be ready. Then as now, we confidently expect to be America's largest producer of barium chemicals for oil additives.

If you are working with lube-oil additives, we would like you to have a copy of this new, 24-page booklet giving complete information on WESTVACO Barium Chemicals. Send for it now.

fmc Westvaco CHEMICALS

Westvaco Mineral Products Division
FOOD MACHINERY AND CHEMICAL CORPORATION
General Offices • 161 East 42nd Street, New York 17
CHICAGO, ILLINOIS • CINCINNATI, OHIO • HOUSTON, TEXAS • NEWARK, CALIFORNIA

(To obtain more data on advertised products see page 1252)



For reforming natural gas **Stainless Steel**

If you could peek inside equipment used for production of synthetic gas and hydrogen, you would see a veritable showplace for Stainless Steel.

Without Stainless Steel tubing and devices, maintenance costs would go through the roof. With Stainless Steel, the greatest freedom from severe petrochemical service is the usual result.

Of course, there is the job of selecting just the right Stainless Steel composition . . . the composition with the best performance cost ratio. This problem is discussed in our booklet, "Performance of Stainless Steel in Petroleum Refinery Service."

Your copy is waiting. Just write to United States Steel, Room 4735, 525 William Penn Place, Pittsburgh 30, Pa., and we shall be glad to send you a copy.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

See "THE UNITED STATES STEEL HOUR"—Televised alternate weeks—Consult your newspaper for time and station.

USS STAINLESS STEEL

SHEETS · STRIP · PLATES
BARS · BILLETS

USS

PIPE · TUBES · WIRE
SPECIAL SECTIONS

UNITED STATES STEEL

Announcing

a new
Tretolite
product
for the
refining
industry

KUPLEX

METAL DEACTIVATOR

Kuplex prevents copper from accelerating the oxidation rate of hydrocarbons which lead to gum and sediment formation. Copper also may react with anti-oxidants in the hydrocarbons to reduce their efficiency. Kuplex combines with dissolved copper in a chelating action which renders the copper inactive.

For samples and complete technical data, ask your Tretolite refinery service engineer or write to

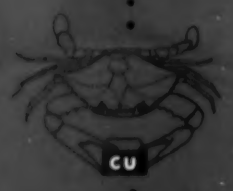
TRETOLITE COMPANY *A Division of Petrolite Corporation*

369 Marshall Avenue, St. Louis 19, Missouri • 5515 Telegraph Road, Los Angeles 22, California

KUPLEX

the new Tretolite metal deactivator

Kuplex deactivates harmful copper and copper compounds by a chelating action. This prevents hydrocarbon deterioration caused by metal catalyzed oxidation. Kuplex prevents the undesirable reactions by combining with the dissolved copper to form a stable chelate. If copper is present, the use of Kuplex will reduce the amount of anti-oxidant necessary to effect desired stability.



Kuplex can be effectively used to deactivate copper in hydrocarbons such as

GASOLINE • KEROSINE
JET FUEL • DIESEL OIL
FURNACE OIL • TURBINE OIL

Kuplex effectively protects the quality of hydrocarbon products for as little as 2 mills per barrel. This insurance against customer dissatisfaction is worth many times its low cost.

For complete technical data, samples and prices, ask your Tretolite refinery service engineer or write to

TRETOLITE COMPANY

A DIVISION OF PETROLITE CORPORATION

369 Marshall Avenue, St. Louis 19, Missouri
5515 Telegraph Road, Los Angeles 22, California

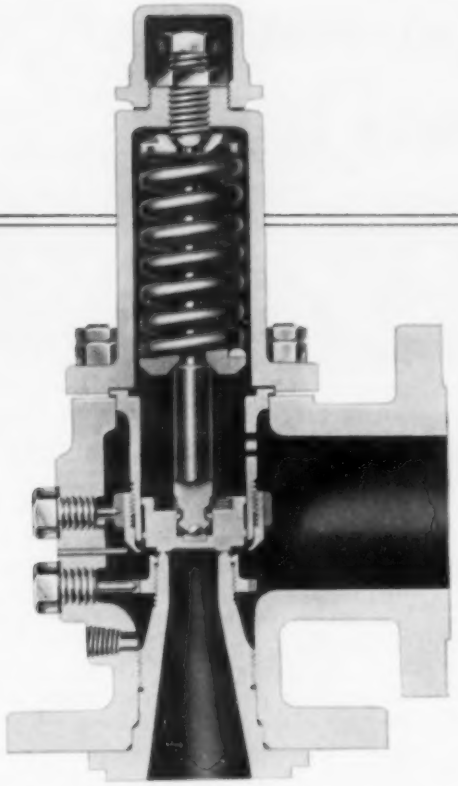
chemicals and services for the petroleum industry

Desalting • Demulsifying • Corrosion Preventives • Scale Inhibiting Asphalt Additives • Fuel Oil Additives • Water De-oiling • Paraffin Removal • Production Stimulation • Bactericides • Metal Conditioners

KU-4

"There is hardly anything in the world that someone cannot make a little worse and sell a little cheaper—and the people who consider price alone are this man's lawful prey."*

John Ruskin



Crosby Full Nozzle Safety Relief Valve, standard in the industry for petroleum, petrochemical, and chemical applications. Send for Catalog No. 300.

* We make our products better but never cheaper . . . striving for quality and performance, rather than the lowest price.

Crosby Steam Gage and Valve Company, 43 Kendrick Street, Wrentham, Mass. . . . manufacturers of Safety Valves, Relief Valves, and Pressure Gages.

Crosby

KEEPS PRESSURE ON THE SAFE SIDE

What Foster Wheeler's

WORLD-WIDE EXPERIENCE

in petroleum processing

means to you

CANADA – Complete refinery with capacity of 23,000 barrels per day.

ENGLAND–Largest refinery in Britain, with capacity of 125,000 barrels per day

UNITED STATES – Synthetic ammonia plant producing 180 T/D of liquid ammonia.

COLOMBIA, S. A. – Completely modernized refinery with capacity of 30,000 bbl per day

PHILIPPINES–Complete refinery with capacity of 13,000 barrels per day.

SOUTH AFRICA–Complete refinery installation – capacity, 15,600 barrels per day.

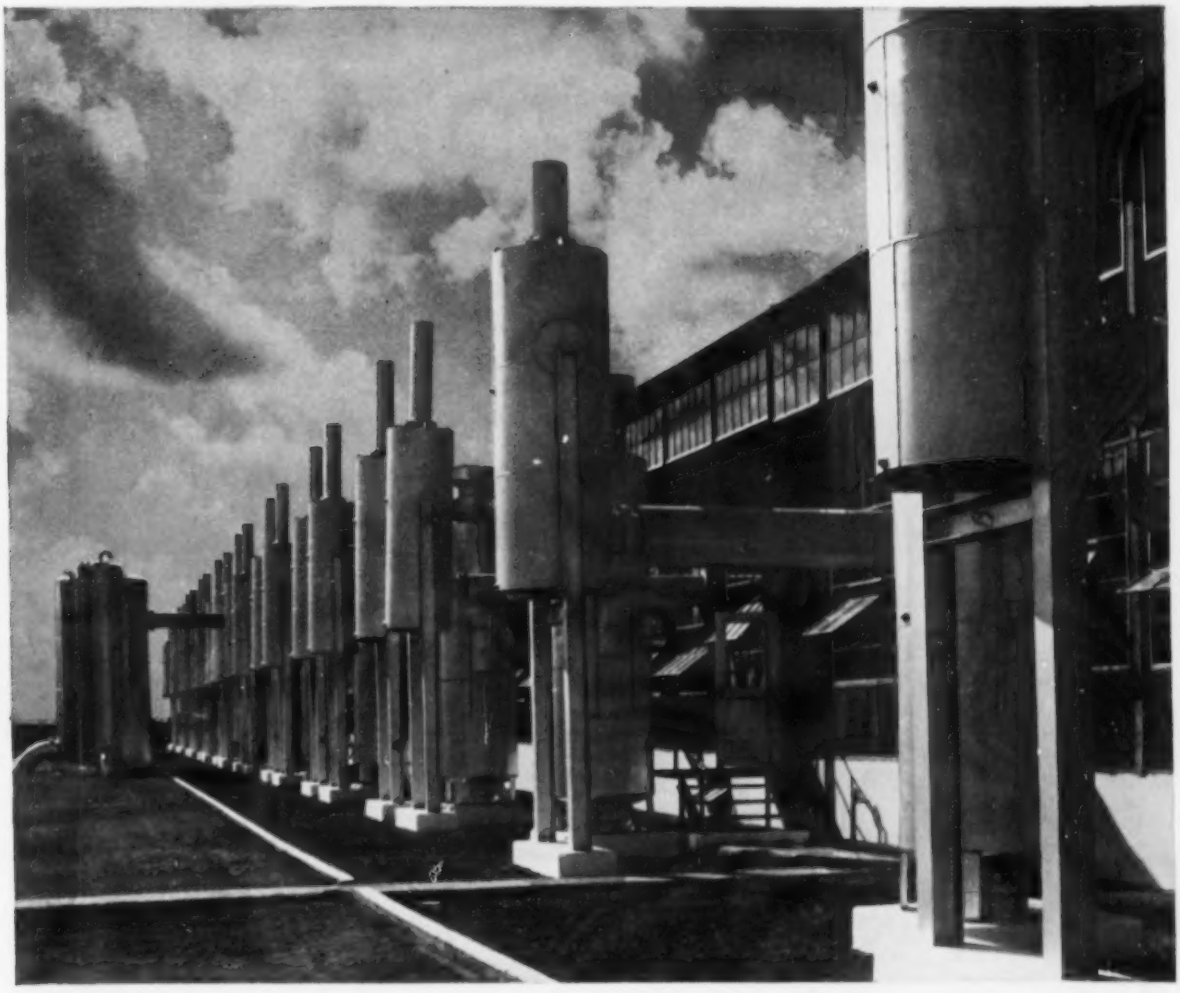
FW has placed in operation during the past year, complete new refineries in U.S.A., South America, South Africa and the Philippines—plus many additional processing units including the largest crude distillation unit ever built and the highest capacity fluid cat cracker in the world. Work is continuing on similar projects in Brazil, Venezuela, England, France, Spain, Bahrein, Canada and the U.S.A.

The experience which this represents is important to petroleum refiners everywhere. Design and construction problems have been solved under a variety of conditions. Working with and training unskilled labor in far countries has developed streamlined and simplified construction procedures. This engineering and construction know-how is constantly being expanded, to encompass the latest technological advances in the petroleum refining and petrochemical fields.

That's why FW can save you time, effort and expense in any phase of process design, construction or modernization. *Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.*

FOSTER WHEELER

LONDON NEW YORK PARIS ST. CATHARINES, ONT.



Kansas Paint & Color Company's Heat-Resisting Aluminum Paint is used on "hot" mufflers at Tennessee Gas Transmission Co.

400°-600° mufflers at East Bernard Compressor Station of Tennessee Gas Transmission Company, Houston, Texas. This company has used Heat-Resisting Silicone Aluminum Paint for more than 10 years.

The Aluminum Paint here is by Kansas Paint & Color Company, Wichita 2, Kansas.

With over 500 hot mufflers in operation, this company has had a lot of experience with high-heat paints. They find that Silicone Aluminum Paint gives fine protection, lasts a long time . . . from 18 to 36 months, depending on the cleaning operation.

Special-formula, high-heat aluminum paints have been developed jointly by ALCOA and leading manufacturers for use in "hot" industrial applications such as this. Paints made to these formulas last longer, cover better, stand up better under high temperatures, corrosive smoke and fumes.

ALCOA does not make paint. But ALCOA Aluminum Pigments are used in more aluminum paints than any other brand. Look for the ALCOA shield on the paint that you buy. It's your assurance of top quality and performance in aluminum paints—top protection for installations throughout the petroleum industry. Write today for information.

Write us about your paint problems. Mail the coupon today. *Free booklets* tell how to paint with aluminum.

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1792-H Alcoa Building, Pittsburgh 19, Pa.
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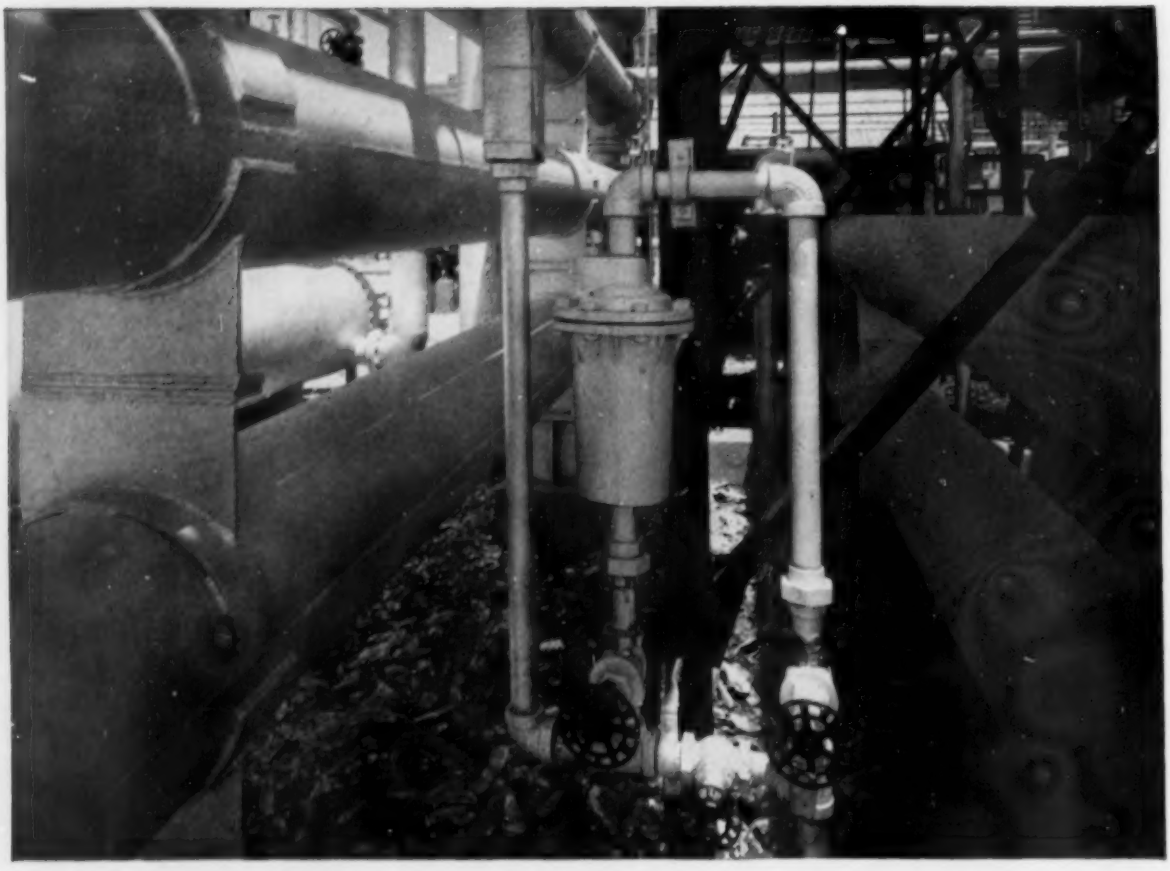
☐ Aluminum Asphalt Roof Coatings Make Time Stand Still

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

(To obtain more data on advertised products see page 1252)



A Trap Designed to Make the P. A. Happy*

P. A. States The Case. The Purchasing Director of a midwestern refinery says: *"The lowest price bid is sometimes not the most economical or desirable one. Often a proper evaluation of other factors reveals quite the contrary to be the case. What we are after is to obtain the lowest overall cost of operating units. Therefore, the first cost of any piece of equipment must be considered together with such other factors as maintenance, safety, durability, flexibility, etc."*

*On the above basis Armstrong traps are certainly designed to please the Purchasing Agent as well as the Superintendents, Engineers, Steamfitters and Maintenance Men:

Installation. Armstrong offers side inlet-side outlet or bottom inlet-top outlet traps in sizes up to 1¼" so hook-ups can be made with minimum labor and fittings. All traps can be equipped with internal check valves, and the three smallest sizes are available with integral strainers. These optional built-in features mean lower installation costs.

Durability. Valves and seats are file-hard chrome steel, ground and lapped together. The other parts are corrosion-resistant stainless steel. Mechanisms in low and medium pressure traps are identical in design, materials and workmanship to those used in traps for 900°F, 900 psig!

Maintenance. Armstrong traps seldom require maintenance. And, they are easily inspected or repaired simply by removing the cap to which the entire mechanism is connected. The body stays in the line. To make a trap new again, simply install a repair assembly straight from the factory production line.

Safety. Every fine-grained cast semi-steel trap is factory-tested at 500 W. S. P. For great resistance to fire, shock and explosion Armstrong offers a complete line of forged steel traps starting at only $20.00 list.

For lowest cost in the long run, Armstrong traps are your best buy. Call your nearby Armstrong Representative or write:

ARMSTRONG MACHINE WORKS
826 Maple Street, Three Rivers, Michigan

Application Engineered
ARMSTRONG STEAM TRAPS

ASK FOR CATALOG J
44-pages of trapping facts and figures, how-to-do-it data and useful information. Free on request.

565

LEADING THE WAY

As they traveled through unfamiliar regions in their prairie schooners, the pioneer settlers of the western regions of America were faced with many uncertainties. For them, the journey was truly a voyage into the unknown.

Innumerable doubts and misgivings can be present, too, when you embark on an important expansion program, particularly when a decision must be reached on the selection of a process construction organization. There can be no turning back after the commitment becomes final.

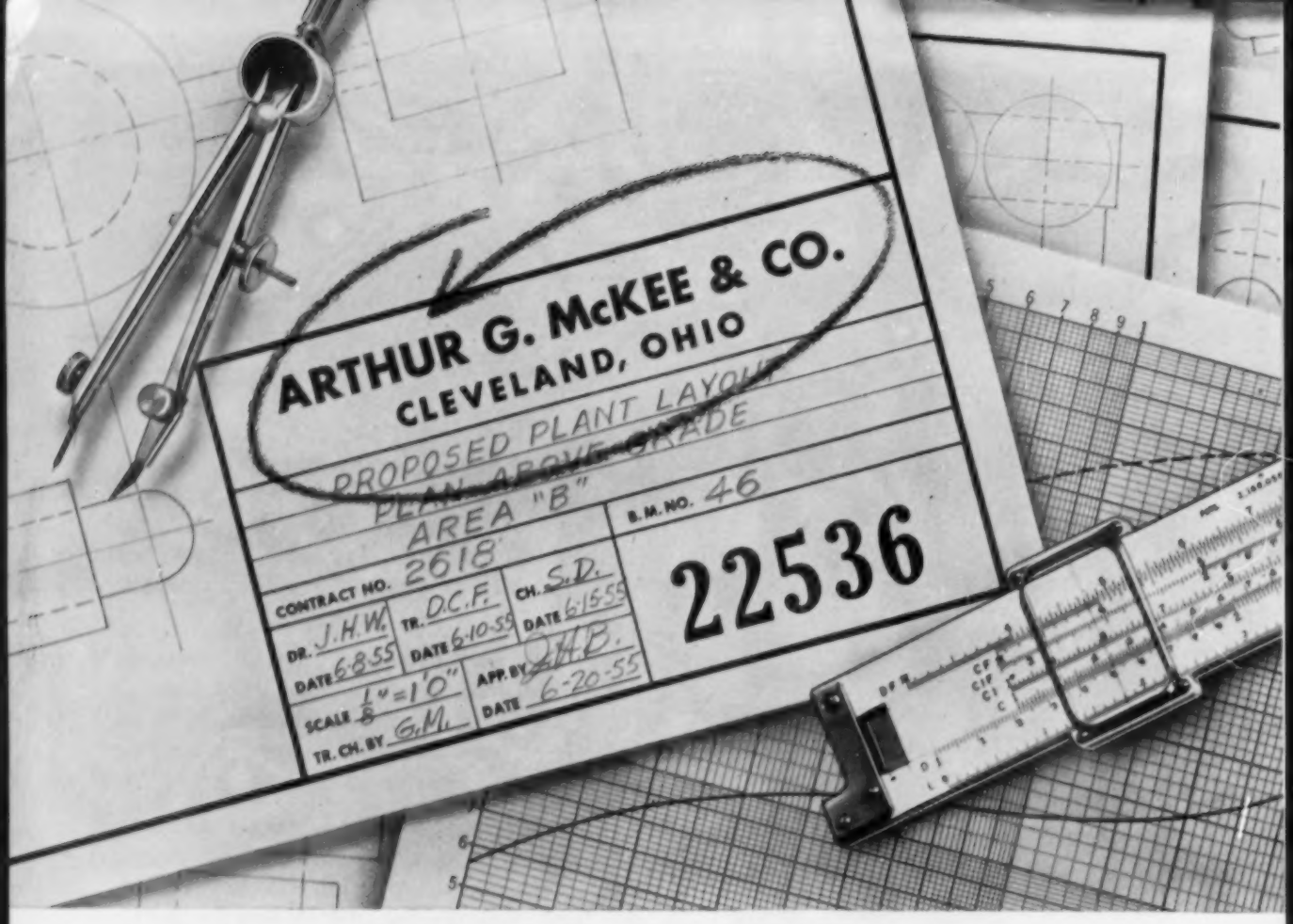
You will be free of this concern when you choose Procon, with its complete design, engineering, and construction facilities. Procon has repeatedly demonstrated its leadership in completing a wide variety of projects according to the specified requirements.

Our engineering staff can show you in detail why your next process construction job should be handled by Procon.

PROCON *Incorporated*

1111 MT. PROSPECT ROAD, DES PLAINES, ILLINOIS
PROCON (CANADA) LIMITED—40 ADVANCE ROAD, TORONTO
PROCON (GREAT BRITAIN) LIMITED—112 STRAND, LONDON
WORLD-WIDE CONSTRUCTION FOR THE PETROLEUM, PETROCHEMICAL, AND CHEMICAL INDUSTRIES

PROCON



THE BEST NAME YOU CAN GET
on the engineering of your new plant

● Compared to the cost of material and construction, the engineering of your new plant represents a small percentage of your investment. Yet the erected value of your plant depends largely on the quality, accuracy and thoroughness of the engineering.

Here at McKee we know from sound, practical experience—a full half-century of it—that meticulous care in engineering pays off in reducing construction man-hours and in making most advantageous use of materials. But, most of all, McKee engineering assures you *correct* plant design and efficient layout—in short, a plant designed and built to earn a profit. When you want the best name you can get on your plant engineering, call in McKee.

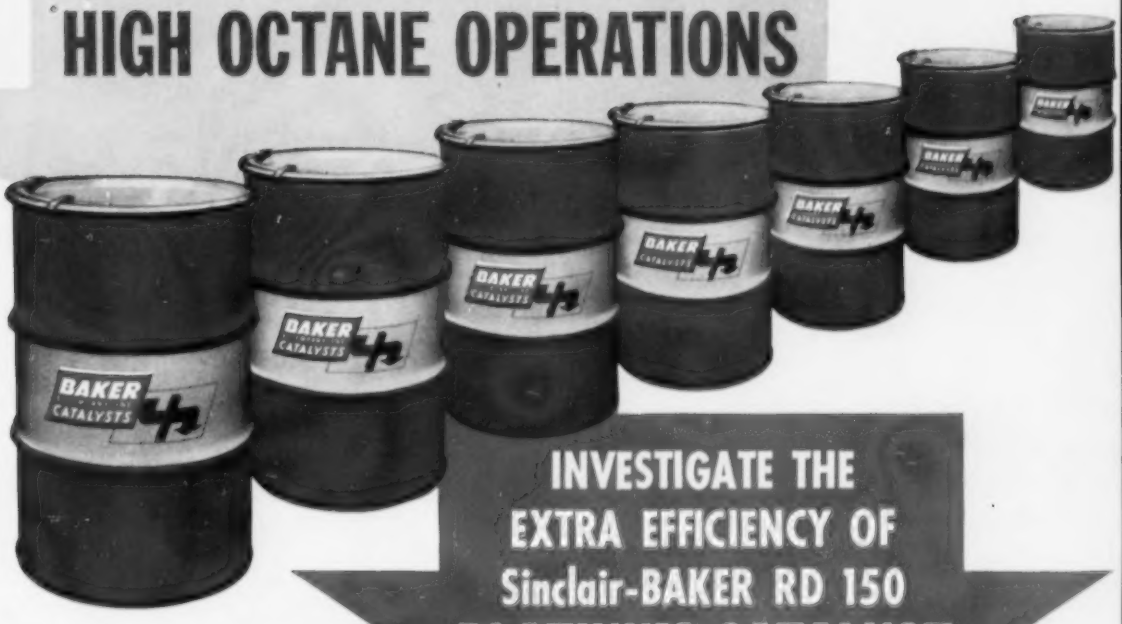
50th ANNIVERSARY

McKee Engineering Services

Arthur G. McKee & Company • Engineers and Contractors

Headquarters: McKee Building • 2300 Chester Avenue • Cleveland 1, Ohio
Offices: New York, N. Y. • Union, New Jersey • Washington, D. C.
British Representatives of Metals Division: Head, Wrightson & Co., Limited
Canada: Arthur G. McKee & Company of Canada, Ltd., 372 Bay St., Toronto

IF YOU ARE CONCERNED WITH HIGH OCTANE OPERATIONS



INVESTIGATE THE EXTRA EFFICIENCY OF Sinclair-BAKER RD 150 PLATINUM CATALYST

BAKER'S RD 150 Platinum Catalyst is a joint development of Baker & Company, Inc. and Sinclair Research Laboratories. This peak-production catalyst is now used with marked advantage by such companies as Sinclair, Socony and Pure Oil.

REGENERATES IN SITU . . . !

RD 150 provides high initial efficiency plus unique regenerative features. RD 150 assures greater yields at high octane levels, exceptionally long periods of operation, PLUS additional economy made possible by regeneration in situ! We are quite confident that the full story of Baker's RD 150 will be intensely interesting to you.

You can also be relieved of delivery and service problems. Modern Baker plants are geared for large-scale manufacture and refining of platinum catalyst.

Upon request, a Baker representative will be glad to consult with you and to furnish detailed information and recommendations.

BAKER & COMPANY, INC. CATALYSTS

113 ASTOR STREET · NEWARK, N. J.

THE HUB OF PLATINUM METALS RESEARCH

DOW

You Can See Why

SARAN LINED PIPE

is your answer to downtime losses

It's made of corrosion-resistant saran pipe swaged right inside rigid steel pipe . . . two pipes in one for longest-lasting performance.

Here's really trouble-free piping . . . saran lined pipe, fittings and valves! This modern piping has a durable inner lining that eliminates shutdowns due to corrosion . . . forms tight-fitting joints that prevent leakage. Saran lined pipe, fittings and valves won't burst under working pressures up to 150 psi . . . and saran lined cast steel fittings are available for even higher pressures. Every single piece of saran lined pipe, fittings and valves is carefully spark-tested by hand to be sure there are no pinpoint holidays or cracks in the lining.

Installation costs are low with saran lined pipe, fittings and valves, too. They can be cut and threaded in the field with modified pipe-fitter's tools. And because they're rigid, few supporting members are needed.

If your operation requires the conveying of acids, alkalies, solvents and other corrosive liquids, be sure to investigate saran lined pipe, fittings and valves today. For further information, write the Saran Lined Pipe Company, 2415 Burdette Avenue, Ferndale 20, Michigan, Dept. SP529F.

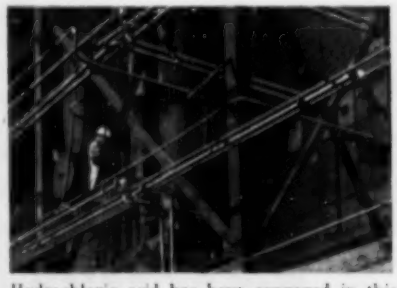
RELATED SARAN PRODUCTS—Saran rubber tank lining • Saran rubber molding stock • Saran tubing and fittings • Saran pipe and fittings.

SOME OF THE MANY INSTALLATIONS USING

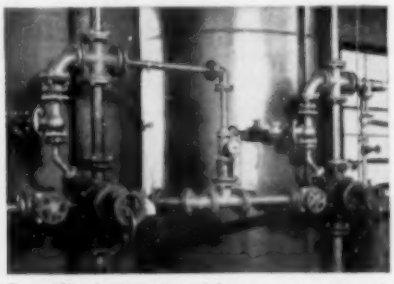
SARAN LINED

STEEL PIPE

Saran Lined Pipe is Manufactured by The Dow Chemical Company Midland, Michigan

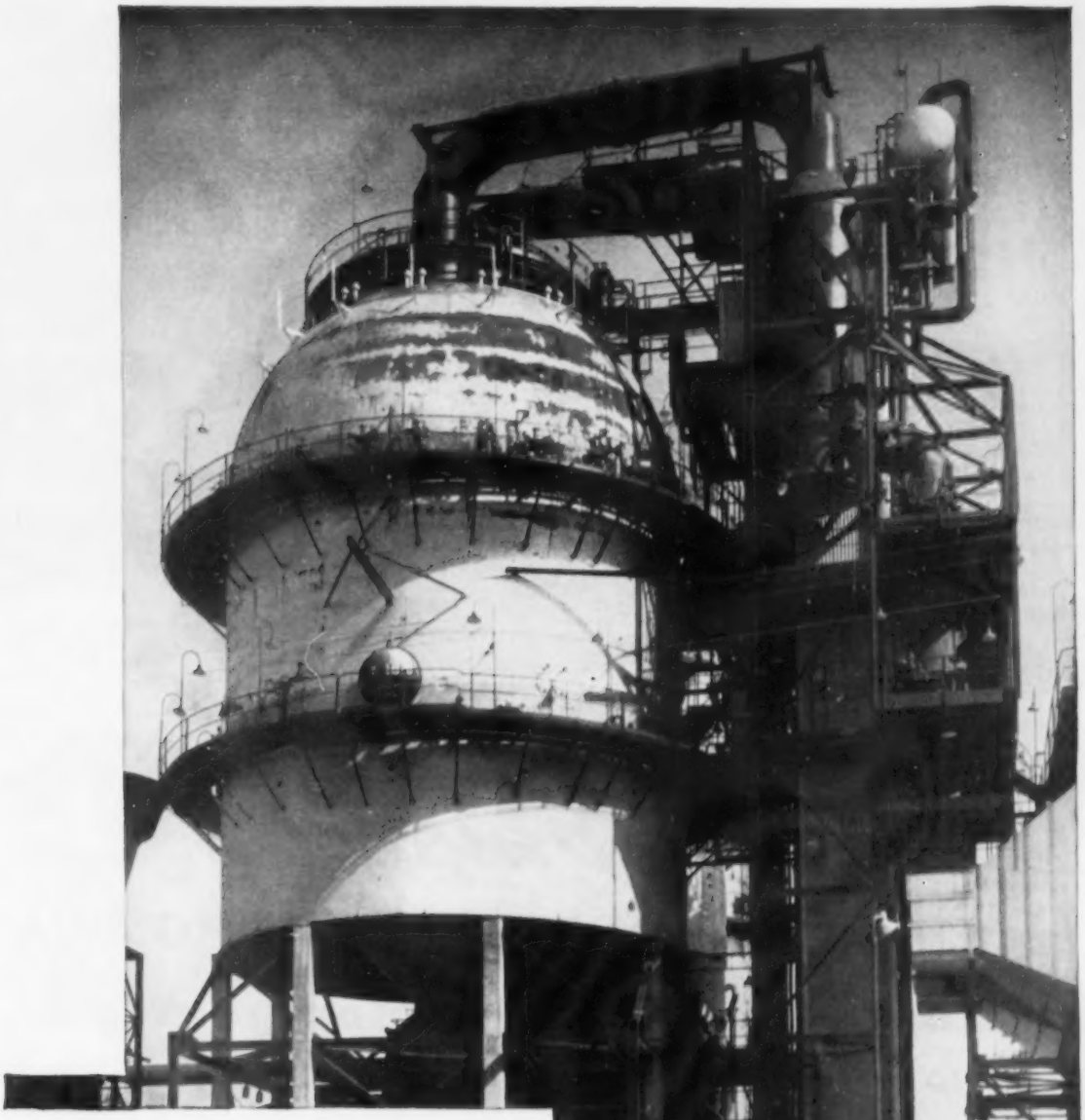


Hydrochloric acid has been conveyed in this installation for well over seven years. Service has been eminently satisfactory.



Saran lined pipe is used here in an automatic water de-ionizer. This installation has also had a long record of uninterrupted service.

you can depend on DOW PLASTICS DOW



BIG CRACKER

The 45-ft. diam. by 30-ft. high regenerator shown here and a reactor and fractionator built by CB&I, are part of the largest Model IV Catalytic Cracking Unit in the world. Furnished through the Fluor Corporation, Ltd. for The Standard Oil Company of California's refinery at El Segundo, California, it has a design capacity of 40,000 B.P.D. The reactor was field stress relieved and X-rayed as was the lower 21 ft. 9 in. shell and bottom head of the fractionator which is clad with 12 per cent chrome.

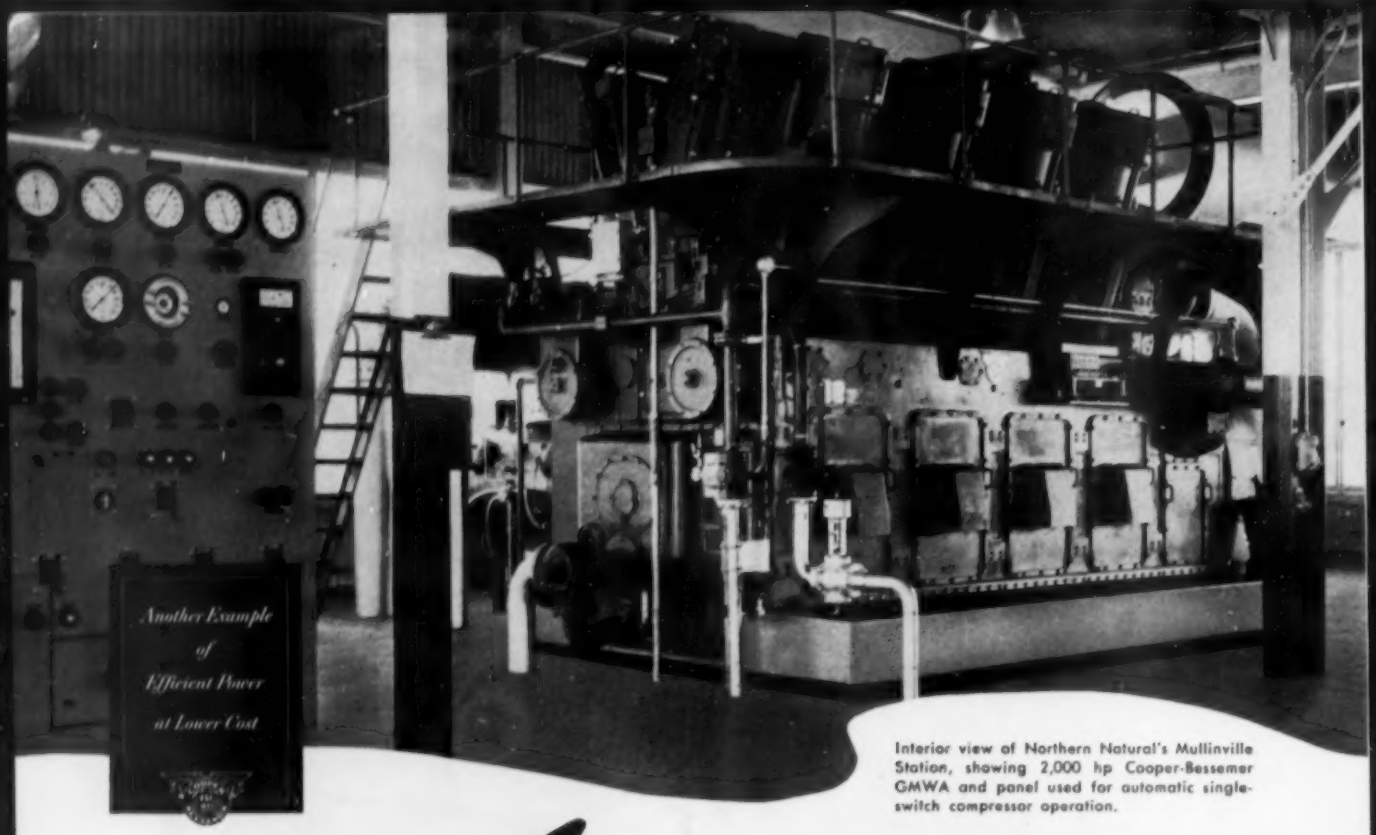
When planning additions, or a new refinery, write Chicago Bridge & Iron Company for information on welded steel plate structures.

CBI

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
Los Angeles • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.

(To obtain more data on advertised products see page 1252)



Interior view of Northern Natural's Mullinville Station, showing 2,000 hp Cooper-Bessemer GMWA and panel used for automatic single-switch compressor operation.

FULLY *Automatic!*

. . . Latest COOPER-BESSEMER GMWA

Compressor Station Development . . .

Now, by merely energizing a *single*-switch control, a 2,000 hp Cooper-Bessemer engine-driven GMWA compressor is started and put on line. That's exactly what takes place at Northern Natural Gas Company's mainline station in Mullinville, Kansas . . . worked out jointly by Northern Natural and Cooper-Bessemer.

This will be welcome news to all who are familiar with the intense competition between different methods of moving gas through pipe lines. It means you can now continue to experience the greatly superior fuel economy of the reciprocating gas engine and at the same time benefit from all the other economies claimed for competing equipment.

Impressive results at Northern Natural are typical of the Cooper-Bessemer development work that continues day after day. Next time you need heavy-duty engines or compressors, first find out about the *newest* advancements being offered by one of America's oldest engine builders . . . Cooper-Bessemer. Detailed information and complete-line bulletins are readily available from the Cooper-Bessemer office nearest you.

MOUNT VERNON, OHIO

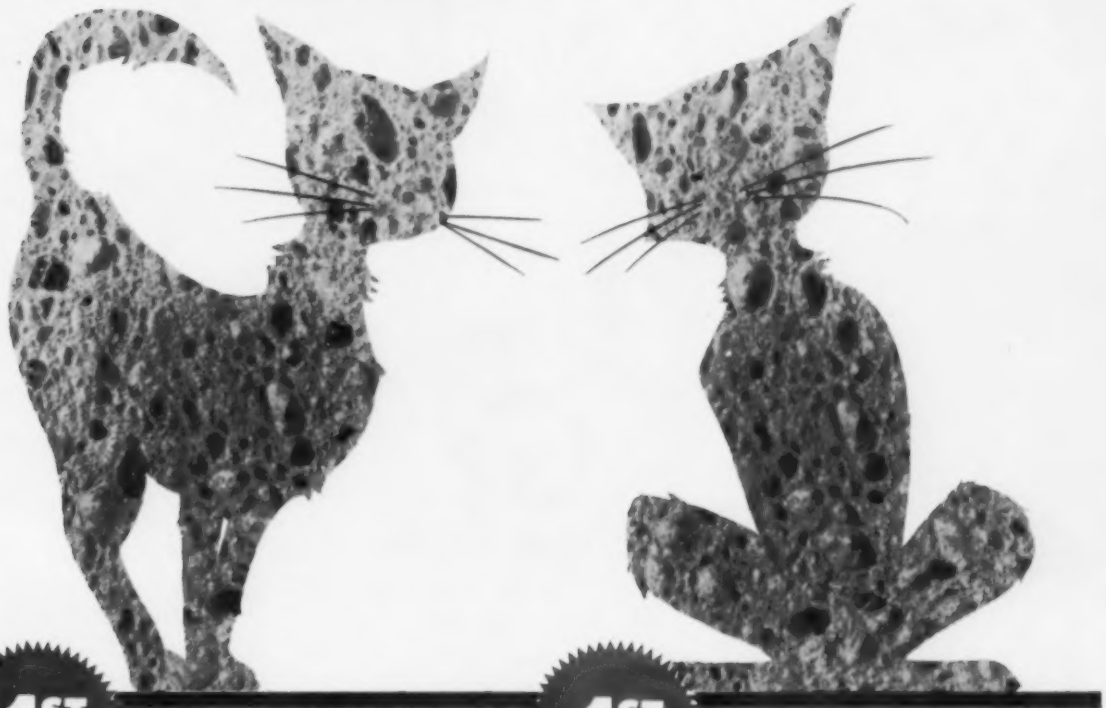
COOPER-BESSEMER

GROVE CITY, PENNA.

New York City • Seattle, Wash. • Bradford, Pa. • Chicago, Ill. Houston, Dallas, Greggton, Pampa and Odessa, Texas Washington, D. C. • Shreveport, La. • San Francisco, Los Angeles, Calif. • St. Louis, Mo. • Gloucester, Mass. • New Orleans, La. • Tulsa, Okla. • Cooper-Bessemer of Canada Ltd., Edmonton, Alberta—Halifax, Nova Scotia.

DIESELS • GAS ENGINES • GAS-DIESELS • ENGINE-DRIVEN AND MOTOR-DRIVEN COMPRESSORS

each FIRST in its class!



1ST

Aerocat®

fluid cracking catalyst

1ST

Aerocat Triple "A"*

high alumina catalyst

both balanced with HIGH PORE VOLUME

Now you get high pore volume in balance with other catalyst properties in both AEROCAT TRIPLE A High Alumina Catalyst and AEROCAT Fluid Cracking Catalyst.

The optimum balance of AEROCAT Catalysts gives you top cracking efficiency whether your process calls for a regular catalyst or our new high alumina catalyst.

Cyanamid has pioneered these catalyst improvements ... first to deliver a commercially successful high alumina catalyst ... first to incorporate high pore volume balanced with other catalyst properties. Ask your Cyanamid representative about HI PV* and how it helps AEROCAT Catalyst help you.

*Trade-mark

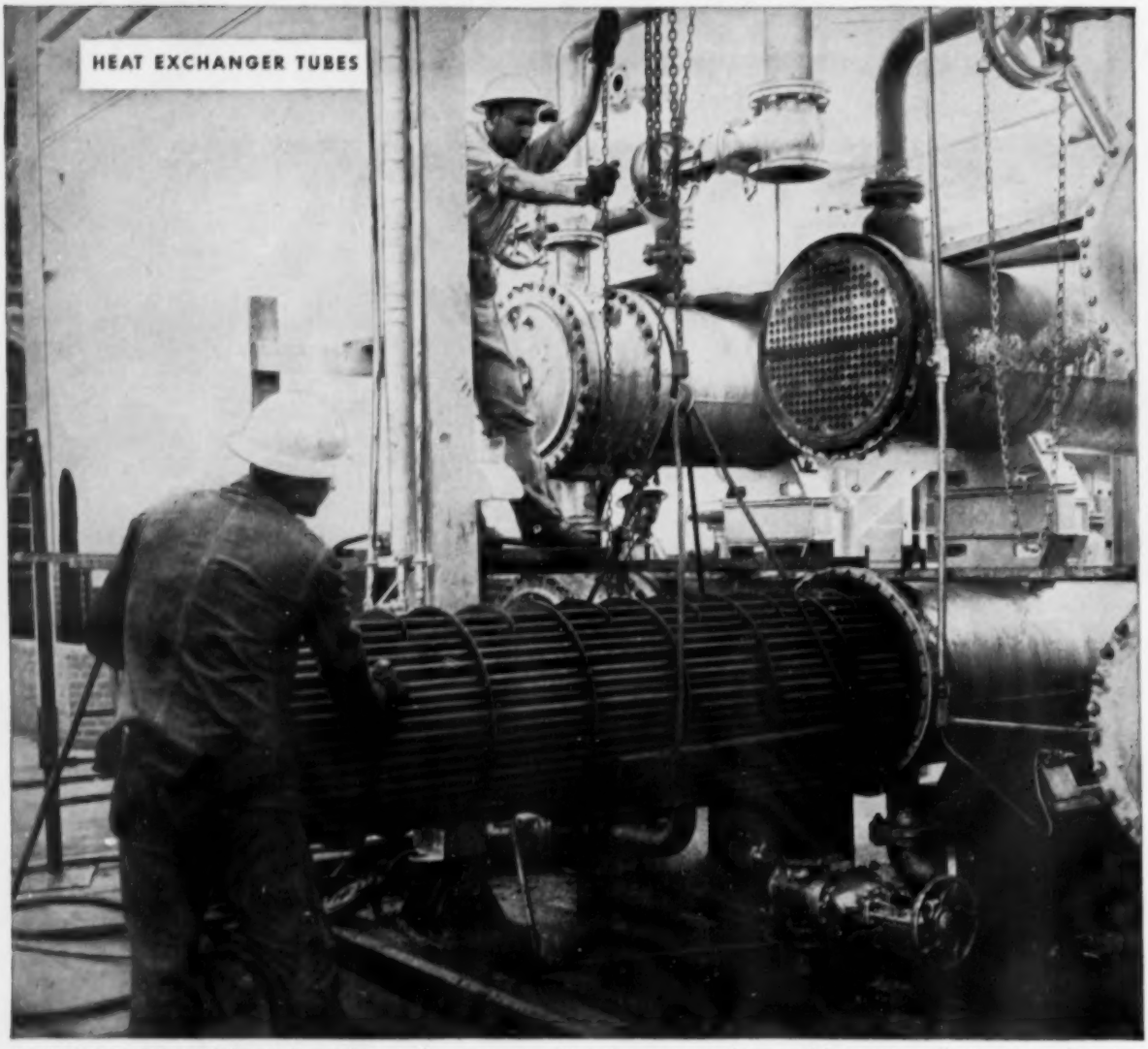
AMERICAN Cyanamid COMPANY

REFINERY CHEMICALS DEPARTMENT

30 Rockefeller Plaza, New York 20, N. Y.

In Canada: North American Cyanamid Limited, Toronto and Montreal

(To obtain more data on advertised products see page 1252)



PERFORMANCE RECORD of these tubes under actual operating conditions is now a part of Anaconda's extensive collection of case histories.

Use of Anaconda Cupro Nickel, 10%-755 Tubes in Texas refinery may answer your tube problem

Imagine a collection of tube performance case histories that can answer many of the corrosion problems you face!

Our files bulge with such a collection. Here is experience accumulated over almost a century. Here are detailed records of tube performance under hundreds of actual operating conditions.

We can put the information in these files to work for you at once—to help you select the one best alloy for your job.

Here's a case history we are now adding—the use of ANACONDA Cupro Nickel, 10%-755* Tubes in the Port Neches Refinery of a major oil producer.

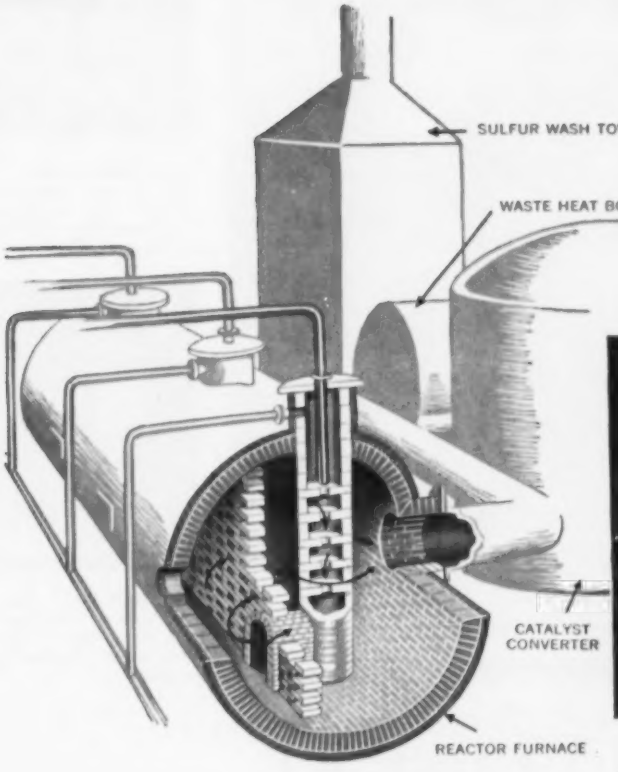
These tubes—in use two years—cool heavy gas oil in an Alco Exchanger on a Crude Pipe Still Unit. Gas oil at about 500°F.—mildly corrosive—comes in contact with the outside of these tubes. Brackish river water—with a high salt content—circulates through the tubes. Yet the tubes show no sign of corrosion.

CUPRO NICKEL, 10%-755 resists corrosion almost as well as Cupro Nickel, 30%-702; yet it costs much less. Polluted sea water and sea water with entrained air—even at relatively high velocity—have little effect on this alloy.

Help for your tube problem. No one tube alloy serves best under all conditions. Your problem is one of choosing the right alloy for the job. Let Anaconda's Technical Department help you. Write, outlining your operating conditions, to Dept. TD, *The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*U.S. Patent No. 2,074,604 54109

ANACONDA®
Tubes and Plates
for Condensers and Heat Exchangers



The dependable Fluor Furnace is the key to a safer sulfur plant

The Fluor furnace is a cylindrical horizontal kiln built in one or more sections with manifold connections for parallel operation. Each section is complete in itself with its own special packing section to assure uniform oxidation. Combustion takes place on the surface of the hot firebrick, eliminating need for burners and preventing unburned H_2S from escaping.

The Fluor sulfur recovery process has a distinct advantage over other methods of producing elemental sulfur from waste hydrogen sulfide because of the design of the Fluor furnace. Outstanding in its simplicity and particularly in its safety factor, the Fluor furnace entirely runs itself. It is not affected by the composition of the gas, by the fluctuations in feed gas rate, or even by a complete interruption of feed gas. It is possible to shut down a Fluor furnace for as long as 60 hours and resume operation simply by readmitting the gas stream. Reaction starts immediately on the surface of the mass of hot brickwork, *leaving no possible chance for unburned H_2S to escape.*

The Fluor reactor furnace is the only one in sulfur plant use today based on recuperative heating. All others employ burners of one sort or another which must be relighted if flame is extinguished due to a fluctuation or interruption of feed gas or for any other reasons. To prevent escape of unburned H_2S, burner-type furnaces are equipped with flame detectors, automatic relighters and other emergency devices which are subject to failure. These are not necessary on a Fluor furnace.

Fluor-built sulfur plants operate at a 400° to 500° F temperature level at the catalyst beds with no danger of flooding the beds with sulfur. With burner-type kilns, should the flame fluctuate and catalyst reaction occur at too low a temperature, the catalyst beds are plugged with liquid sulfur, requiring shutdown. Catalyst in the Fluor process need only be changed every 3 to 5 years.

The Fluor furnace can handle much leaner gases than other processes. If economically feasible, the Fluor process can recover sulfur from an H_2S gas stream with a sulfur concentration as low as 15% (dry basis). An internal brickwork recuperative-heat exchanger incorporated into the furnace makes this possible. The temperature of the feed gas is preheated sufficiently before it reaches the reaction zone for more thorough combustion. This feature is exclusive with the Fluor design.

The first sulfur plant on this continent utilizing this process was built by Fluor for the Southern Acid and Sulfur Company in 1942. It is still in operation, producing a high grade (99.97%) sulfur. Since then Fluor has built a significant number of sulfur conversion units with equal success.

BE SURE WITH **FLUOR**

THE FLUOR CORPORATION, LTD
LOS ANGELES 22, CALIFORNIA
FLUOR OF CANADA - TORONTO
HEAD WRIGHTSON - LONDON

ENGINEERS
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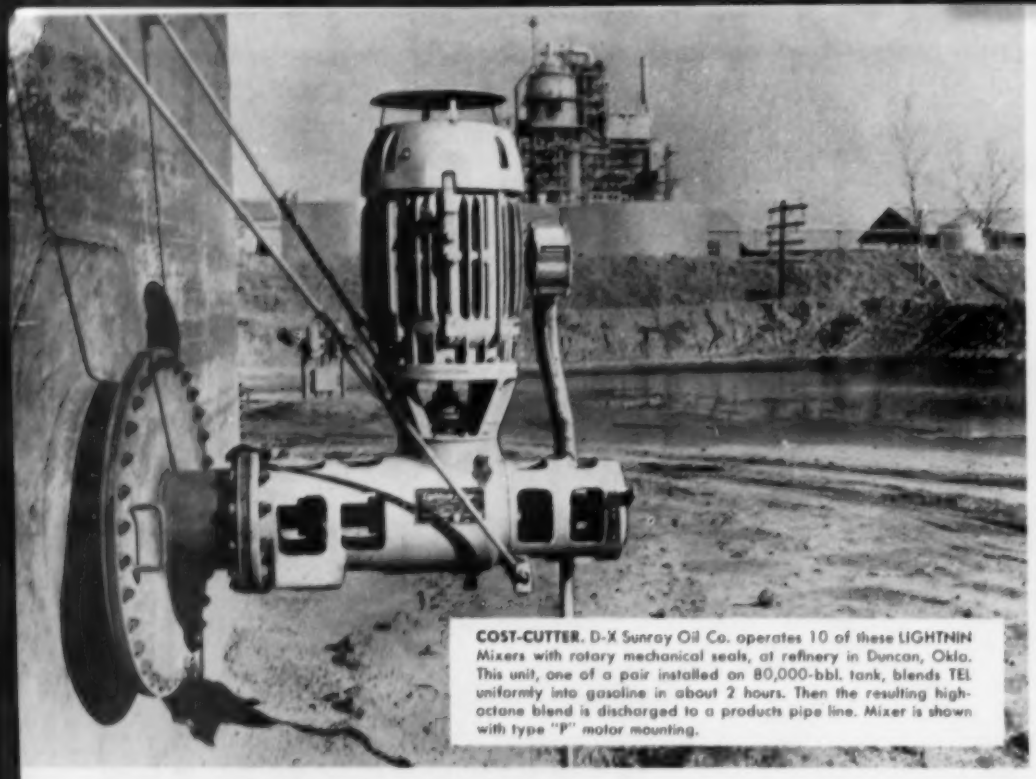
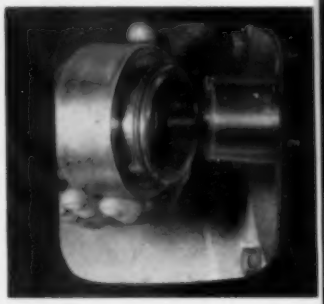


COST-CUTTER. D-X Sunray Oil Co. operates 10 of these LIGHTNIN Mixers with rotary mechanical seals, at refinery in Duncan, Okla. This unit, one of a pair installed on 80,000-bbl. tank, blends TEL uniformly into gasoline in about 2 hours. Then the resulting high-octane blend is discharged to a products pipe line. Mixer is shown with type "P" motor mounting.

MIXER SHUTOFF closes like a valve to keep liquid in the tank while seal is being changed. No need to drain the tank. One man can replace seal in a few minutes.



CARTRIDGE SEAL slides off shaft. New seal cartridge goes in its place. Taper on shaft insures correct alignment when recoupling.

No stuffing box to repack!

How D-X Sunray Oil Co. slashes mixer upkeep with new, easy-to-replace LIGHTNIN Mechanical Seals

D-X Sunray Oil's maintenance men hardly ever touch this LIGHTNIN Side Entering Mixer.

It *never* needs repacking. There's no stuffing box to fiddle with. And there's *no leakage.*

In place of a stuffing box, this LIGHTNIN has a quickly-removable cartridge-type rotary seal. This new LIGHTNIN Seal positively stops product leakage. It runs for *years* without attention.

But if the seal ever needs to be replaced, *one man* can replace it in a few minutes. And he does it without draining the tank, without demounting or dismantling the mixer.

Does it work? Judge for yourself: after trying out two of these LIGHTNINs at its refinery in Duncan, Okla., Sunray has purchased *eight more* of the same type, for installation on new tanks.

Get solid maintenance savings

You can cut maintenance cost, and stop product drippage around your tanks, too—by specifying LIGHTNIN Mixers with the new, easy-to-replace LIGHTNIN rotary mechanical seal. Some users are saving *as much as 90%* of the time and money once spent on stuffing box upkeep.

There are other mechanical reasons, too, why LIGHTNINs are your best equipment buy for the long pull. For instance, you can't ever lose alignment of parts in a LIGHTNIN. Positive alignment is built in, for keeps, with concentric rabbet fits that mean smoother running, often for 20 years and more.

And LIGHTNINs give you extra safety with *hollow-quill power* transmission on gear drive Models SE. *Two* separate sets of heavy-duty bearings—one to carry transmission loads only, one to take the brunt of mixer shaft loads. A flexible coupling links shaft and quill, to protect gearing from *any* sudden shock or strain on the shaft.

You get your choice, too, of seals *or* stuffing boxes to fit the job—with or without positive, easy-operating tank shutoff device that permits seal change or repacking without losing a pint of product.

Your LIGHTNIN Mixer representative will be glad to give you the full story on how LIGHTNINs for *your* tanks, new or old, can help you avoid shutdowns and reduce maintenance cost. He's listed in your copy of The Refinery Catalog. Why not give him a call today?

Get the cost-cutting facts now . . . New 8-page Bulletin B-111 shows how you get maintenance-free sealing that really slashes fluid mixing cost to a new low. Send also for LIGHTNIN Mixer catalogs listed here. Free—no obligation. Just check data you want, tear out and mail to us today with your name and company address.

- ☐ B-102 Top Entering Mixers (turbine and paddle types)
- ☐ B-103 Top Entering Mixers (propeller types)
- ☐ B-104 Side Entering Mixers
- ☐ B-107 Mixing Data Sheet
- ☐ B-108 Portable Mixers (electric and air driven)
- ☐ B-110 Condensed Catalog (complete line)
- ☐ B-111 LIGHTNIN Rotary Mechanical Seals
- ☐ B-112 Laboratory Mixers

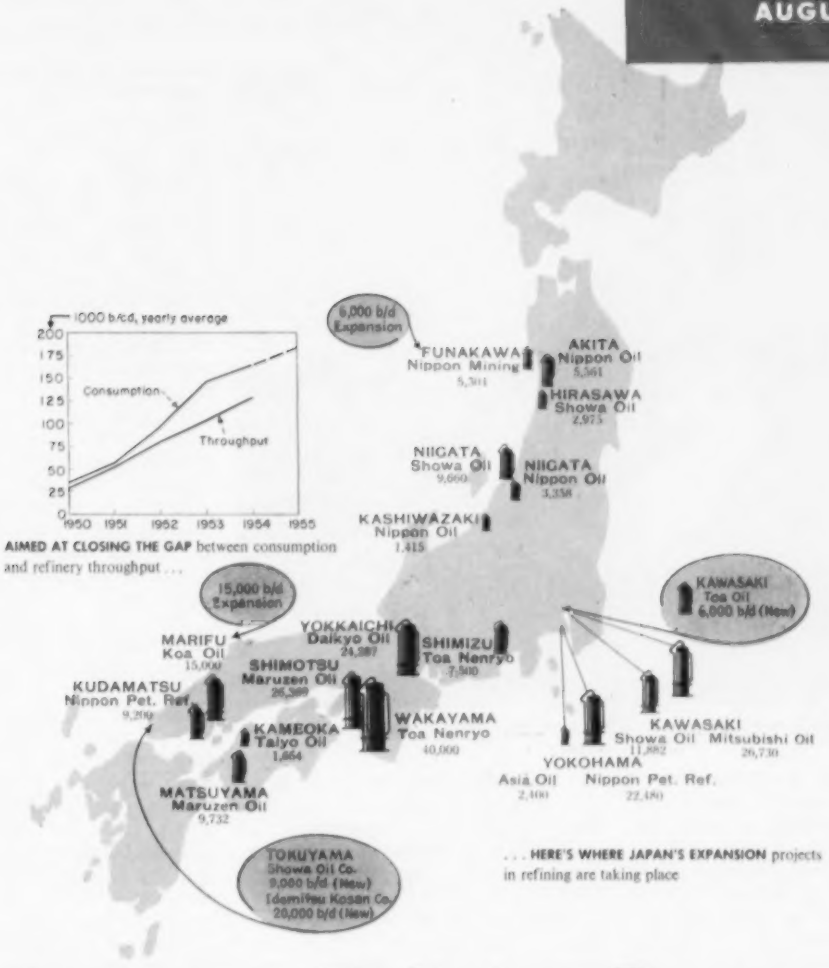
MIXING EQUIPMENT Co., Inc., 131-h Mt. Read Blvd., Rochester 11, N. Y.

In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.

Lightnin® Mixers

MIXCO fluid mixing specialists

Petroleum Processing
AUGUST 1955



AIMED AT CLOSING THE GAP between consumption and refinery throughput . . .

. . . **HERE'S WHERE JAPAN'S EXPANSION** projects in refining are taking place

Japanese Refining Booms

Demand seen climbing at 10% a year rate, with consumption on an upgrade since 1950

A Staff Report by the Editors of PETROLEUM PROCESSING

JAPAN'S petroleum industry is straining at the seams. With demand for oil products gradually increasing, pressure for expansion of refining capacity is also mounting.

Refining has grown by over 300% since before the war, to a capacity of 225,507 b/d in 1955. Almost this entire increase represents new additions made since 1950, moreover, for at the peak of the second World War capacity reached only 71,007 b/d.

Investment since 1951 is estimated at a total of $107,000,000. This does not include money for petrochemical expansion, but does cover projects under way or being planned. Some authorities believe that this relatively firm construction, along with other "talking stage" projects, could boost Japan's refining capacity to 327,000 b/d.

Next to the U. S., this looks like peanuts, no doubt. But such comparisons have little meaning when they involve countries with as great a disparity in kind and quantity of natural resources, let alone in size and population.

The status of Japan's refining industry today can be read in the graph and map above and tables on the following pages. The map shows the concentration of refineries on Japan's Pacific Coast and around the cities of Kawasaki, Yokohama and Wakayama. In addition, it shows where new refineries are to be built and existing plants

JAPANESE USE BIKES TOO for getting around plants. This is topping unit at the Marifu refinery

to be enlarged. Japan will have a total of 21 refineries and 13 refining companies in its petroleum processing industry when expansion is complete.

Three entirely new refineries are to be constructed. One will be at Kawasaki, near Yokohama, for Toa Oil Co. The other two are tentatively planned for a site at Tokuyama and are for Showa Oil Co. and Idemitsu Kosan Co. Expansion of existing facilities is under way at Koa Oil's Marifu refinery and at the Funakawa plant of Nippon Mining Co. The accompanying table shows details of all of these projects.

Besides the crude capacity of 225,507 b/d mentioned above, the industry has facilities for catalytic reforming of 10,270 b/d, catalytic cracking of 8600 b/d (soon to be enlarged by 13,500 b/d), and solvent treating of 18,359 b/d.

Consumption has been rising above all previous levels since 1952, and production by the refineries has spurted ahead to meet the challenge. Today, refining falls short of demand only in gasoline, heavy fuel oil and lube oils.

But demand remains strong for all products, and refiners expect to see it go on climbing by 10% a year, owing to economic reconstruction still in progress, the larger numbers of vehicles and ships, the growing needs of the country's armed forces, and other factors. Specifically, consumption of oil products in 1955 will amount to about 66,500,000 bbl., of which 15,500,000 bbl. will be imported.

Japan's own wells, it should be explained, produced only 4.1% of crude throughput in 1954. While a long-range exploration and drilling program is planned, no one expects production to be more than tripled at best, leaving the great bulk of crude requirements still to be obtained by import.

Right now the government maintains imports of refined products largely as a concession to the big trading companies, which would be severely hurt if the imports were cut off suddenly.

The government says it intends to diminish these gradually and after 1960 will only import small quantities of high octane gasoline. Although crude imports have been increased steadily—from almost 10,000,000 bbl. in 1950 to just under 47,000,000, bbl. in 1954—this still left about 36% of Japan's refining capacity unused in the latter year, and refiners are pressing the government to allocate more foreign exchange for crude. This year's purchases will bring in an estimated 51,000,000 bbl.

A more serious situation is the government's developing opposition to the industry's further expansion. Officials say that, at present, more capacity would simply add to the facilities already standing idle, which is true, in view of the government's current import policy.

Behind this attitude, though, is the opposition of coal interests, who fear the growing incursions of the petroleum and natural gas industries. Coal and lignite have for a long time supplied the bulk of Japan's energy needs, and still do; but they are losing ground to petroleum and natural gas at a time when no other energy source is.

Right now coal interests seem to have won some governmental influence to their cause, as may be seen in a proposal soon to come before the Japanese Parliament, or Diet, to enact a tariff of 6.5% on heavy fuel oil and 2% on crude. The move is expected to succeed, despite the fact that the former is the shortest in supply of the oil products.

This show of strength won't daunt the refiners, though. Instead they are pushing ahead with further investment and hope that the huge increase in facilities will act to loosen the government's grip on foreign exchange for crude. Also, some of them expect to begin exporting refined products in the near future, and want more capacity for this purpose. The government may encourage this trend, reasoning that the exports would earn enough currency to offset the larger crude purchases they would necessitate.

Southeast Asian markets will be the first objective for most of the interested companies; but one, Nippon Petroleum Refining Co. (50% owned by Caltex), is anticipating "exports" within Japan. These would be to American armed forces stationed on the islands which now must buy from the United States.

Where does Japan get her imports? Middle East crude made up 76.9% of crude imports in 1954. Far East sources contributed 19.7%, North America 2%, and Europe and South America each under 1%.

In refined products, 52.9% came from the Middle East in the same year, 37.5% from North America, 8.1% from the Far East, and the rest from South America, Europe and other areas.

Besides large imports of crude oil and products, Japan's petroleum industry has been thriving on substantial injections of foreign capital, largely American. Most of the investment has been made since 1950, when after a change in occupation policy the big

Current Status and Planned Expansion — Japan's Refineries

Company & Refinery Location	Investment for facilities	Crude Throughput Capacity b/d	Thermal Cracking b/d	Catalytic Cracking b/d	Catalytic Reforming b/d	Solvent Dewaxing b/d	Solvent Extraction b/d	Solvent Deasphalting b/d
Nippon Oil Co.	$5,367,000							
Akita		5,561	1,006					
Niigata		3,358						
Kashiwazaki		1,415						
Nippon Petroleum Refining Co.	24,939,000							
Yokohama		22,480		5,600		3,554	315	3,500
Kudamatsu		9,200			1,300	760	400	
Showa Oil Co.	3,625,000							
Kawasaki		11,882			1,500	500	1,000	
Hirasawa		2,975						
Niigata		9,660						
Tokuyama	(9,750,000)*	(9,000)*						
Toa Nenryo Kogyo Co.	19,936,000							
Shimizu		7,500				500		
Wakayama		40,000	3,500	(10,000)	4,670	1,120	1,720	660
Maruzen Oil Co.	4,489,000							
Shimotsu		26,369		3,000		500	1,000	
Matsuyama		9,732						
Mitsubishi Oil Co.	11,975,000							
Kawasaki		26,730	3,000		1,500	600	430	
Koa Oil Co.	4,438,000	(15,000)						
Marifu		15,000	3,000		1,300			
Daikyo Oil Co.	3,750,000							
Yokkaichi		24,287		(3,500)		1,200		
Asia Oil Co.								
Yokohama		2,400						
Taiyo Oil Co.								
Kameoka		1,654						
Nippon Mining Co.	1,555,000	(6,000)						
Funakawa		5,304				600		
Toa Oil Co.								
Kawasaki	(900,000)	(6,000)						
Idemitsu Kosan Co. (trading company)								
Tokuyama	(16,000,000)	(20,000)						
Totals as of Apr. 1, 1955	$80,074,000	225,507	10,506	8,600	10,270	9,334	4,865	4,160
Units under construction or being planned	($26,650,000)	(56,000)		(13,500)				

* Figures in parentheses are units under construction or planned.

refineries on Japan's Pacific Coast were reopened. Today, in the nine leading refining companies, foreign sources provide 29.1% of the total investment. These affiliations are shown in greater detail in the table.

Once the major refineries reopened, efforts were turned to building cracking, reforming, and solvent refining facilities so as to produce the high octane gasoline and high-grade lubricating oils which were being supplied mainly by imports.

The first stage saw the completion of UOP Platforming units at the Kudamatsu refinery of Nippon Petroleum Refining Co. and at the Marifu refinery of Koa Oil Co. in December of 1953. Within the next half year two more Platformers had been put in, one at the Kawasaki refinery of Showa Oil Co., the other at the Kawasaki refinery of Mitsubishi Oil Co.

In December of 1954 Esso Research and Engineering Co. installed a Fluid hydroforming plant at the Wakayama plant of Toa Nenryo Kogyo, boosting Japan's total reforming capacity to 10,270 b/d.

Japan's Consumption of Petroleum Products 1950-1955

(in bbls./yr.)

	1950	1951	1952	1953	1954	1955*
Gasoline	2,603,783	4,699,774	9,089,016	12,504,101	14,643,121	17,173,800
Kerosene	483,739	845,296	736,236	2,213,656	2,961,485	3,699,200
Gas Oil	1,312,472	2,206,499	2,607,828	3,534,148	4,132,900	5,197,500
Heavy Fuel Oil	7,000,150	11,571,997	19,663,333	31,937,812	35,149,432	36,855,000
Lube Oils	1,256,553	1,554,940	1,808,440	2,195,965	2,333,318	2,457,000
Others	506,375	563,245	834,101	1,061,946	1,115,723	1,197,000
Total	13,163,072	21,441,751	34,738,954	53,447,628	60,335,979	66,579,000

* 1955 figures are estimates of demand.

Ownership of Nine Major Japanese Oil Companies

Company	Japanese % Interest	Foreign Affiliate
Toa Nenryo Kogyo Co.	55	Standard Vacuum Oil Co.
Nippon Petroleum Refining Co.	50	California-Texas Co. (Caltex)
Showa Oil Co.	50	Anglo-Saxon Petroleum Co. (Royal Dutch-Shell associate)
Koa Oil Co.	50*	Caltex Oil Products Co.
Mitsubishi Oil Co.	50	Tide Water Associated Oil Co.
Nippon Oil Co.	..	Totally Japanese-owned
Maruzen Oil Co.	..	Totally Japanese-owned
Nippon Kogyo Mining Co.	..	Totally Japanese-owned
Daikyo Oil Co.	..	Totally Japanese-owned
TOTAL	29.1	(Foreign affiliates hold 29.1% interest in the total Japanese oil industry)

* Other 50% owned by Nippon Oil Co.

The construction of catalytic cracking plants began late in 1954, the first being a Model IV Fluid cracker designed by Esso Research for the Yokohama refinery of Nippon Petroleum and erected in December. Four months later a UOP Fluid cracker was installed in the Shimotsu refinery of Maruzen Oil Co., and a Houdriflow cracker was completed only last May at Daikyo Oil Co.'s Yokkaichi refinery. Toa Nenryo has plans for building a 10,000 b/d Fluid cracker at its Wakayama refinery.

What are the refiners' plans for further future construction? One area in which they don't run up against opposition is petrochemicals. Here the government is all smiles and encouragement, for a domestic petrochemical industry would do much to relieve the foreign exchange problem, without stepping on the toes of rival industries. The detailed story of Japan's petrochemical expansion may be found elsewhere on this page.

Enlargement of the refining industry in addition to construction already under way depends on a number of projects which are currently being discussed or negotiated with the government. Some of the most important of these are summarized below:

Showa Oil Co., which is 50% owned by the Anglo-Saxon Petroleum Co. (a Royal Dutch-Shell associate), may participate in the construction of a new 30,000 b/d refinery with the Mitsubishi Chemical Co., Shell's chemical affiliate. It will be closely linked with a petrochemical facility Mitsubishi and Anglo-Saxon hope to build and which Showa has agreed to join as a supplier of products but not capital. For the refinery, Showa would provide half the $19,500,000 capital.

The companies want to build both facilities on the site of a former naval fuel depot at Tokuyama. Showa has already purchased a small part of the Tokuyama property from the government and may begin erection of the refinery next fall, with completion scheduled for June of 1957. The company wants to buy at least a part of the still unsold section of the depot for the projected petrochemical plant.

Idemitsu Kosan Co. is an oil trading firm which hopes to build a 20,000 b/d refinery, also at the Tokuyama site, through a tie-in with the Iranian Oil Co. It is believed that Idemitsu has already applied for a $6,000,000 to $7,000,000 loan from the Bank of America to cover part of the costs of the refinery, which should total some $16,000,000, and two 30,000-ton super-tankers to bring oil from Iran. Construction of the refinery would start about six months after governmental approval and would be completed in about two years.

Japanese Petrochemicals Get the "Go" Sign

THE Japanese government has given full encouragement to the development of a domestic petrochemical industry because of the sharp upturn in demand since 1953.

At present, the only petrochemicals produced in full-scale are methanol—12,000 ton/yr.; and formaldehyde—7200 ton/yr., by the Nippon Gas Chemical Industry Co., using natural gas as a raw material.

Oil companies are losing no time, however, in expansion plans. Four leading firms have current plans for an expenditure of about $10,000,000 on petrochemical facilities. The government is expected to approve these projects soon, and three of the companies hope to begin construction this coming fall, with completion by next spring in the realm of possibility.

The government intends to assist this industry's rapid growth by preventing dual investment and competition among products. Here are some of the details on imminent expansion.

Maruzen Oil Co. will invest $1,720,000 in facilities for making:

Propane, ton/yr.	2700
Isopropyl alcohol, ton/yr.	2400
Butane and isobutylene, ton/yr.	10,000
Isobutyl alcohol, ton/yr.	4560
Methyl-ethyl alcohol, ton/yr.	3600

Nippon Oil Co. will spend about $2,200,000 on a plant to make:

Acetone, ton/yr.	5000
Isopropyl alcohol, ton/yr.	2000
Methyl isobutyl ketone, ton/yr.	1500

Some of Nippon's raw materials will come from its own refineries; others will come from Nippon Petroleum Refining Co. plants.

Mitsubishi Oil Co. has budgeted $2,700,000 for the production of 10,000 ton/yr. of aromatics:

Benzene, ton/yr.	4000
Toluene, ton/yr.	3000
Xylenes, ton/yr.	3000

Koa Oil Co. will begin its expansion later than the other firms, because it is to be joined in the venture by seven former Mitsui companies (the original firm was disbanded by authorities during the Occupation). Koa will contribute about $2,700,000 of the total $7,000,000 required for the projected joint enterprise. Products of the 17,520 b/d plant are to be:

Polyethylene, ton/yr.	3600
Ethylene glycol, ton/yr.	2400
Acetone, ton/yr.	4320
Phenol, ton/yr.	7200

Mitsubishi Chemical Co. and the Anglo-Saxon Petroleum Co. have planned a collaboration on a petrochemical plant to cost about $11,000,000. It will be capitalized equally between the two companies. The products will be supplied by Showa Oil Co. The project is still tentative, owing to difficulties with the Japanese government over the plant site. Products to be made have not yet been disclosed.

Estimated Japanese Demand for Petrochemical Products

(Tons per year)

	1953	1954	1955
Ethylene Group:			
Ethylene oxide	620	800	1,250
Ethylene glycol	1,100	1,160	1,240
Diethylene and triethylene glycol	300	350	490
Polyethylene glycol	350	400	620
Ethylene glycol ether	570	715	900
Polyethylene	614	2,000	3,000
Styrene monomer	10	25	130
Totals	3,564	5,450	7,630
Propylene Group:			
Isopropyl alcohol	375	450	1,250
Acetone	3,750	4,260	5,210
Methyl isobutyl ketone & diisobutyl ketone	1,700	1,870	2,050
Propylene glycol	500	530	610
Totals	6,325	7,110	9,120
Butylene Group:			
Methyl-ethyl ketone	720	740	600
Butanol	7,380	8,630	10,730
Totals	8,100	9,370	11,330
Aromatic Group:			
Benzene	34,353	30,295	37,757
Toluene	7,987	7,885	8,800
Xylene	3,030	3,313	3,900
Solvent grade benzene	18,125	17,607	17,730
Solvent naphtha	5,979	6,008	6,561
Synthetic phenol	6,607	8,703	14,096
Totals	76,081	73,811	88,844

You Can Use van der Waals and Wohl Equations

Dr. Hobson

Dr. Weber

"Good design work in many instances requires good volumetric data," authors Hobson and Weber point out in the first paragraph of their article.

"When experimental data are lacking—which is the usual case for gaseous mixtures—the volumetric behavior is generally estimated by using Kay's method to predict the pseudo-critical properties and the generalized compressibility factor. It has been demonstrated in this work that the van der Waals and Wohl equations predict volumetric data which are of comparable accuracy, and in some cases, more precise than those obtained by Kay's method.

"In many instances, an explicit equation of state presents the P-V-T relationship in the most convenient form. This is particularly true in considering changes of state at constant composition. Once the constants for a given mixture have been established, such quantities as work, heat, and many thermodynamic functions may be calculated analytically."

Merk Hobson is associate professor of chemical engineering at the University of Nebraska. He received his B.S. degree in 1943 from the University of Wisconsin, and his Ph.D. in 1951 from Northwestern.

Dr. Hobson has been associated with Esso Standard Oil Co. (La.) and the Pure Oil Co. during his professional career. He is a member of the American Chemical Society, American Institute of Chemical Engineers, and American Society for Engineering Education.

James H. Weber, also associate professor of chemical engineering at the University of Nebraska, has been a previous contributor to PETROLEUM PROCESSING ("Predict Isothermal Enthalpy Changes," Jan., 1955, pp. 83-85, and "Temperature-Enthalpy Data for Ethylbenzene," April, 1954, pp. 545-547).

Dr. Weber received his chemical engineering education at the University of Pittsburgh, B.S. in 1941, M.S. in 1947, and Ph.D. in 1948. He is a member of the ACS, ASEE, AIChEE, and Sigma Xi, and is engaged in consulting work.

For Gaseous Mixtures . . .

Predicting Volumetric Behavior

By MERK HOBSON and JAMES H. WEBER
University of Nebraska

THE problem of predicting the volumetric behavior of gaseous mixtures is one that often confronts the design engineer. In compressor calculations, all types of fluid flow calculations, in sizing fractionating columns, and in many other instances good design requires accurate volumetric data.

At the present time, the method recommended by Kay[4], which uses the generalized compressibility factor as determined from pseudo-reduced properties, is the one most frequently applied. In this paper, the accuracy of Kay's method is compared with that of the van der Waals and the Wohl equations of state; as these two relationships are applied to gaseous mixtures. The comparisons have been made for superheated and saturated vapors.

The choice of the van der Waals and Wohl equations of state was made largely on the basis of simplicity. Also,

Table 1—Summary of Binary Systems Investigated

System	Reference	Range of Compositions, mole %		Range of Temp. °F.	Range of Press., psia.
Methane[a] Ethane	(12)	50.71	CH_4	70-250	14.7-800
Methane[a] Propane	(11)	20-80	CH_4	68-194	147-441
Methane[a, b] n-Butane	(13)	20-80	CH_4	70-250	100-800
Methane[a] n-Pentane	(14)	94.05-73.90	CH_4	100-460	200-600
Propane[a] Propylene	(8)	18.69-83.45	C_3H_6	212-437	100-800
Ethane[a] Nitrogen	(10)	27.33-73.18	N_2	40-400	200-800
Ethylene[a] Nitrogen	(10)	27.33-73.18	N_2	40-400	200-800
Propane[a] Nitrogen	(16)	16.6-68.1	N_2	259-300	92.2-634.5
Ethane[b] n-Butane	(6)	17.49-82.18	C_4H_{10}	30.5-272.1	75-700
Ethane[b] n-Heptane	(5)	26.54-88.71	C_7H_{16}	153.0-478.1	50-700

(a)—Comparisons made on superheated vapors.
(b)—Comparisons made on saturated vapors.

Table 2—Methane-Ethane System

Vapor phase mole fraction of $CH_4 = 0.5071$

Pressure, psia.	Per Cent Error					
	Kay's Method		Van der Waals eqn.		Wohl eqn.	
	70°F.	250°F.	70°F.	250°F.	70°F.	250°F.
14.7	+0.10	−0.05	−0.07	−0.07	−0.07	0.00
100	+1.03	+0.10	−0.53	−0.60	−0.58	−0.11
200	+2.12	+0.61	−1.10	−1.25	−1.15	−0.20
400	+1.48	+0.15	−2.58	−2.58	−1.90	−0.38
600	+1.12	+0.25	−5.08	−4.08	−2.45	−0.47
800	+1.09	+0.34	−9.83	−5.57	−2.69	−0.52

each of these equations contains no more than three arbitrary constants in addition to the universal gas constant, R, and offers approximately the same degree of precision as the theory of corresponding states.

Obviously, both the Beattie-Bridgman and the Benedict-Rubin-Webb equations of state would produce more accurate results than the equations used in this work, but they contain five and eight constants respectively, and would not ordinarily be used by the process design engineer.

The comparisons of the equations of state and Kay's method were made over a pressure range of 14.7 to 800 psia. The selection of this pressure range is justified, because most operating pressures fall within these limits.

To determine the degree of accuracy obtainable by the three methods, Kay's and the van der Waals and Wohl equations, the results predicted by their use have been compared with experimental data on the following systems in the superheated region:

Hydrocarbon-Hydrocarbon	Hydrocarbon-Nitrogen
Methane-Ethane	Ethane-Nitrogen
Methane-Propane	Ethylene-Nitrogen
Methane-n-Butane	Propane-Nitrogen
Methane-n-Pentane	
Propane-Propylene	

Similar comparisons have been made on the saturated vapors for the following systems:

Methane-n-Butane
Ethane-n-Butane
Ethane-n-Heptane

While these systems are not all the binaries that have been investigated experimentally, they do represent a significant portion of them and certainly the results presented show the accuracy that may reasonably be expected from these methods of calculations.

To use the van der Waals equation,

$$\left(P + \frac{a}{V^2}\right)(V - b) = RT \quad \ldots\ldots (1)$$

for the determination of the volumetric behavior of gaseous mixtures, a method of evaluating the constants, a and b, for the mixture is necessary. A number of investigators have attempted to predict these terms for the mixtures from the constants of pure materials and a combination of the terms to account for the interaction of the molecules of the two gases. In previous investigations three methods have been proposed for the evaluation of the parameters a and b for gaseous mixtures. The simplest of these is a linear combination:

$$b_x = b_1x_1 + b_2x_2 \quad \ldots\ldots (2)$$

where b_x is the value of the parameter b for the mixture. This combination was recommended by van der Waals[15] and Berthelot[1] for the determination of b_x. However, van der Waals more frequently used the Lorentz[9] combination to evaluate b_x:

$$b_x = b_1x_1^2 + 2x_1x_2\left(\tfrac{1}{2}\sqrt[3]{b_1} + \tfrac{1}{2}\sqrt[3]{b_2}\right)^3 + b_2x_2^2 \quad \ldots\ldots (3)$$

Van der Waals[15] recommended a third type of combination for the cohesive constant, a; namely, the relationship:

$$a_x = a_1x_1 + 2a_{12}x_1x_2 + a_2x_2 \quad \ldots\ldots (4)$$

where a_{12} is an interaction constant and cannot be determined from a_1 and a_2. Later, Galitzine[2] determined the interaction constant from the relationship:

$$a_{12} = \sqrt{a_1a_2} \quad \ldots\ldots (5)$$

If equation (5) is substituted in equation (4), the result is:

$$a_x = a_1x_1^2 + 2\,a_1a_2\,x_1x_2 + a_2x_2^2 \quad \ldots\ldots (6)$$

$$\sqrt{a_x} = \sqrt{a_1}x_1 + \sqrt{a_2}x_2 \quad \ldots\ldots (6a)$$

This is a linear combination of the square roots of the constants. In this work equation (3) was used to calculate the parameter b for the gaseous mixture and equation (6), the parameter a. This selection of the linear combination of square roots of the constants was based on references (2) and (15), cited above.

The Wohl equation in the form:

$$P = \frac{RT}{V-b'} - \frac{a'}{TV\,(V-b')} + \frac{c'}{T^2V^2} \quad \ldots\ldots (7)$$

was used in this work. This form was presented by Wohl[17] in 1914 and shows that the constants a' and c' are functions of temperature. All the constants, a', b', and c', may be evaluated in terms of the critical constants. The relationships are:

$$a' = 6P_cT_cV_c^2 \quad \ldots\ldots (8)$$

$$b' = V_c/4 \quad \ldots\ldots (9)$$

$$c' = 4P_cT_c^2V_c^3 \quad \ldots\ldots (10)$$

If the values of the constants are substituted into equation (7) at the critical condition, the critical ratio, RT_c/P_cV_c is shown to be equal to 3.75. As brought out by Kobe and Rosenberg[7], this is in good agreement with the experimental values for many substances. In their work on

the application of the Wohl equation to the behavior of pure substances, Kobe and Rosenberg calculated a Wohl critical volume V_c'.

$$V_c' = RT_c/3.75\,P_c \quad \ldots\ldots (11)$$

Critical volumes calculated in this manner, rather than those reported in the literature, were used to determine the constants of the Wohl equation. A similar procedure was followed in this work. The Wohl constants for the gaseous mixture were calculated by equation (2), the linear combination.

The ranges of compositions, temperatures, and pressures over which the volumetric behavior was predicted by Kay's method and the van der Waals and Wohl equations of state are reported in Table 1 for the various binaries. Also, reference is made to the literature source of the experimental data, which served as the basis of comparison for the determination of the accuracy of predicting volumetric behavior by Kay's method and the van der Waals and Wohl equations.

Of the total of 594 datum tested, 551 involved superheated vapors and 43 saturated vapors. Referring to the former case, there are a number of distinct trends apparent from the results. First, the volumes predicted by the equations of state tend to be below those determined experimentally. Further, if the temperature and composition are fixed, the percentage error in the volume obtained by these equations increases with increased pressure. If the temperature is now increased and the same range of pressures considered, the magnitude of the error is decreased, but the trend remains the same.

When the van der Waals and Wohl equations are applied to pure gases, the results follow the same pattern. The compressibility factors predicted by Kay's method tend to be greater than the experimental values.

To illustrate the points brought out above, representative values obtained on the methane-ethane system are reported in Table 2. For saturated vapors, all the methods of prediction used in the investigation yielded results which were consistently high; i.e., the predicted volumes were greater than the actual.

Table 3 offers a means of comparing the accuracy of the three methods based upon the average absolute error in the predicted volumes. These errors are given over two pressure ranges, in the one case, up to 800 psia. and in the other, to 400 psia. The majority of refinery operations are limited to the lower pressure range.

Considering first the case of superheated vapors, it can be concluded that the average error of Kay's method is nearly independent of the pressure range. Conversely, the accuracy of the equations of state is definitely improved, if the pressure range is limited. Finally, all the methods used are reasonably accurate for the prediction of the volumetric behavior of gaseous mixtures in the superheated region.

In contrast to the accuracy of the results obtained on superheated vapors, those on saturated vapors were rather unreliable. An average error below 3% is the exception and an error above 5% is common. No one method appears to be the most accurate, and all leave something to be desired.

Table 3—Summary of Results

System	Method of Calculation	Aver. Abs. Error (%) Complete Pressure Range	Aver. Abs. Error (%) P=400 psia.
Superheated Vapors			
Methane Ethane	Kay's van der Waals eqn. Wohl eqn.	0.59 (84)* 2.38 0.71	0.53 (56)* 0.91 0.40
Methane Propane	Kay's van der Waals eqn. Wohl eqn.	2.58 (14)* 2.36 4.44	2.46 (12)* 3.98 2.08
Methane n-Butane	Kay's van der Waals eqn. Wohl eqn.	3.60 (33)* 2.04 0.41	3.52 (24)* 2.08 0.33
Methane n-Pentane	Kay's van der Waals eqn. Wohl eqn.	1.80 (14) 0.86 1.23	1.86 (9)* 0.57 1.47
Propane Propylene	Kay's van der Waals eqn. Wohl eqn.	2.13 (229)* 2.40 0.97	1.06 (116)* 0.72 0.41
Ethane Nitrogen	Kay's van der Waals eqn. Wohl eqn.	0.83 (92)* 1.69 2.01	0.82 (46)* 1.03 1.34
Ethylene Nitrogen	Kay's van der Waals eqn. Wohl eqn.	0.74 (57)* 0.70 0.88	0.64 (44)* 0.47 0.61
Propane Nitrogen	Kay's van der Waals eqn. Wohl eqn.	1.21 (28)* 1.74 2.92	1.07 (20)* 1.19 2.50
Saturated Vapors			
Methane n-Butane	Kay's van der Waals eqn. Wohl eqn.	8.8 (13)* 7.0 1.7	6.4 (9)* 7.0 2.0
Ethane n-Butane	Kay's van der Waals eqn. Wohl eqn.	7.25 (17)* 5.84 5.73	5.76 (10)* 3.6 7.3
Ethane n-Heptane	Kay's van der Waals eqn. Wohl eqn.	15.3 (13)* 3.4 12.3	9.2 (8)* 4.5 3.5

* Figure in parentheses is number of datum included in average.

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NOMENCLATURE

P=pressure, psia.
R=gas law constant, 10.73 psia.-cu. ft./lb. mole-°R.
T=temperature, °R.
V=volume, cu. ft./lb. mole.
a and b=constants of the van der Waals eqn.
a', b', and c'=constants of the Wohl eqn.
t=temperature, °F.
y=mole fraction in the vapor phase.

Subscripts

c=refers to property at the critical point.

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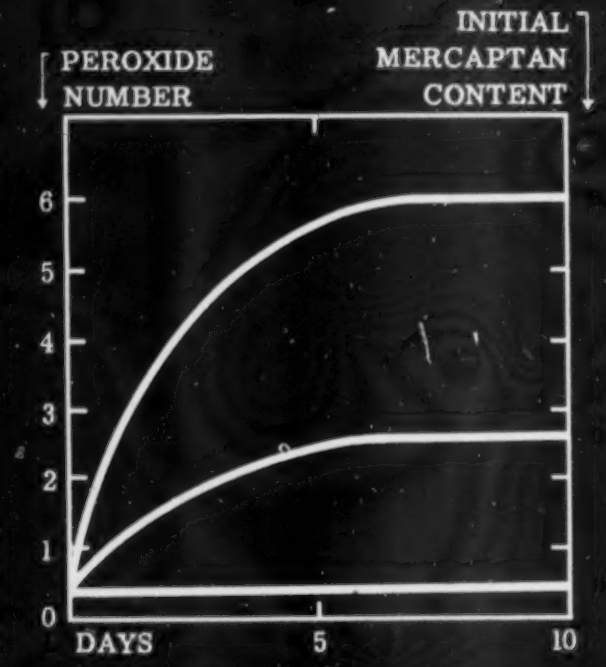
0.005
0.000
DAYS
5
10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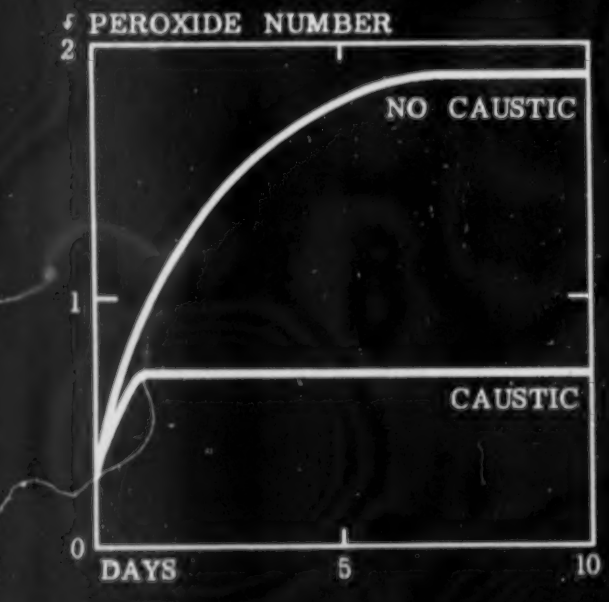
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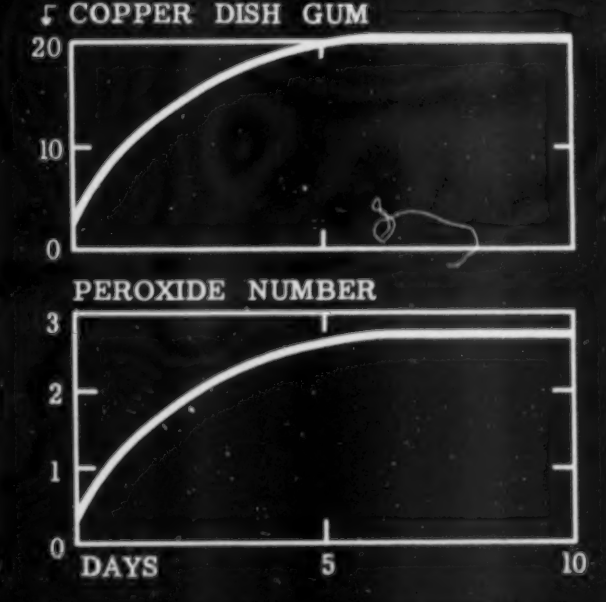
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PEROXIDE NUMBER
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DAYS
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10

Fundamentals on the mechanism of the process, its good and its bad features

By L. D. RAMPINO
and
M. J. GORHAM
Tide Water Associated Oil Co.

INHIBITOR sweetening is a process for getting rid of the mercaptan odor of cracked gasolines. It has both good features and bad features.

What are these bad features and what can be done to improve this process? What is the mechanism of inhibitor sweetening?

Commercially the process is usually conducted in the following way: A sour gasoline—one containing mercaptans—is inhibited with phenylene diamine type of inhibitor and then caustic-washed. This gasoline is then allowed to stand in a storage tank until it is sweet, that is, until all the mercaptans have disappeared.

The basic process was discovered in 1946 at the Tide Water Associated Oil Co. Avon Refinery, Associated, Calif. It is simple and cheap to operate and is widely used in the petroleum industry for sweetening cracked gasolines.

The laboratory apparatus used for studying sweetening was a brown-glass, quart bottle. Gasoline was placed in the bottle, and the bottle then capped with a grooved cork to allow access to air. When gasoline was stored in the presence of caustic, no agitation was employed. Samples were withdrawn from the bottle, from time to time, for various tests.

Experimental Data

Peroxide formation during inhibitor sweetening: Fig. 1 shows a very characteristic feature of the inhibitor sweetening process. The bottom curve shows the rate of mercaptan disappearance; the top curve shows the rate at which peroxides are formed. Note that as mercaptans disappear from the gasoline, peroxides are simultaneously formed. When sweetening is complete, peroxide formation levels off.

This experiment was performed, in absence of caustic, with a sample of light thermal gasoline inhibited with 7.5 lbs. of phenylene diamine type of inhibitor per 1000 bbls. of gasoline.

To check the effect of mercaptan disappearance on peroxide formation, two experiments were performed: in one, outside mercaptans were intentionally added to the gasoline; in the other, mercaptans were completely removed from the gasoline. Fig. 2 shows the results obtained.

The middle curve is the same curve as that shown in Fig. 1. Note that when normal butyl mercaptan was added to the gasoline used to obtain the middle curve, peroxide formation leveled off at a higher point as shown by the top curve. The bottom curve shows what happened when mercaptans were removed from the original gasoline by extraction with alcoholic caustic: peroxide formation was extremely low.

The experiments described so far refer to sweetening in absence of caustic. Fig. 3 shows the effect of conducting sweetening in presence of caustic.

In this experiment, light catalytic gasoline and caustic were placed in a brown bottle and allowed to stand with no agitation. It can be seen that peroxide content was lowered by the presence of caustic. One effect of caustic is to extract part of the mercaptans from the gasoline and thereby lower mercaptan concentration, and as was shown before, less peroxides are formed in the gasoline when the initial mercaptan concentration is lowered. Another effect of caustic is to greatly accelerate the rate of sweetening; this will be discussed later.

The data so far presented show that inhibitor sweetening leads to peroxide formation.

Copper dish gum: Fig. 4 shows the effect of peroxide formation on copper dish gum. It can be seen that as peroxides formed in the gasoline, copper dish gum increased. The copper dish gum is the amount of gum left after evaporating 100 cc. of gasoline in a copper dish. This experiment was performed with light thermal gasoline. Other kinds of gasolines also showed that peroxides raise the copper dish gum.

Engine cleanliness: Peroxides not only raise copper dish gum. They also affect engine cleanliness. This is shown as follows:

Sweetened Gasoline	Peroxide Number	Engine Cleanliness (100 Perfect)
NO. 1	0.9	78.5
NO. 2	0.25	89.5
NO. 3	0.9	79.0

These data were obtained from a moderate temperature, moderate speed, high BMEP (Brake Mean Effective Pressure) engine test on inhibitor-sweetened light catalytic gasoline sampled in the refinery at different dates. They suggest that peroxides lead to dirtier engines. Detailed examination of the engine showed peroxides made the induction system dirtier and increased the number of stuck and tight rings.

To summarize the data up to this point, we may say that inhibitor sweetening leads to peroxides formation; peroxides increase copper dish gum and contribute to engine fouling.

Mechanism of sweetening: The table shows some of the reactions that take place when a sour, inhibited gasoline is stored in absence of caustic.

Production of free radicals: According to the scheme shown in the table, the first step leading to sweetening is the formation of a free radical from the gasoline. This radical can react with oxygen to form a peroxy radical. Free radicals can also be produced by the dissociation of peroxides.

Inhibitor radicals are formed when free radicals produced by the first two reactions abstract one hydrogen atom from an inhibitor molecule.

Mercaptyl radicals are formed when either a gasoline radical or an inhibitor radical abstracts a hydrogen atom from RSH; the latter reaction leads to a regeneration of inhibitor.

Mercaptan disappearance: Mercaptyl radicals can disappear from the system by combining with each other. Mercaptyl radicals can also disappear by adding to an olefin; this gives rise to a new radical which can react with oxygen to form a peroxy radical.

Peroxide formation: Peroxides are formed when peroxy radicals abstract a hydrogen atom from either a mercaptan or from an inhibitor molecule. Peroxides are also formed when peroxy radical abstracts a hydrogen atom from

the inhibitor radical. The loss of a hydrogen atom from the inhibitor radical leads to inhibitor disappearance. In the imide form, the original inhibitor molecule, H In H, has lost its two hydrogen atoms.

According to the scheme presented in the table for sweetening in presence of inhibitor (caustic absent) a number of predictions can be made. These predictions have been verified by experimental data. For example:

One would predict that the ability of a gasoline to form peroxides plays a key role in determining how fast free radicals are formed. Since free radicals lead to the formation of mercaptyl radicals, one may say that the ability of a gasoline to be oxidized determines how fast mercaptans disappear in the gasoline.

It is known, for example, that cat cracked gasolines form peroxides very easily; also, that mercaptans disappear easily in this type of gasoline. By contrast, straight run gasolines form peroxides extremely slowly and as is generally known, mercaptans disappear extremely slowly in this type of gasoline.

It is instructive to compare the effect of different kinds of inhibitor on peroxide formation. Aminophenol type of inhibitor and especially the hindered phenol type suppress peroxide formation; they also suppress sweetening.

Our data show that a sour cat cracked gasoline inhibited with a hindered phenol, and stored in absence of caustic, showed no change in mercaptan content after standing one month. Phenylene diamine type of inhibitor permits a certain amount of peroxides to form in the gasoline even when mercaptans are removed from the gasoline. It is also the inhibitor specified for inhibitor sweetening.

According to the second reaction shown in the table, one would predict that peroxides would accelerate the rate of sweetening. This was borne out by experiments in which mercaptans were added to a gasoline after inhibitor sweetening had occurred, that is, after peroxides had formed in the gasoline, we noticed that mercaptans disappeared very quickly.

One would also predict that the removal of all peroxides from a sour gasoline would slow down the rate of sweetening. To remove peroxides, use was made of a not too well known property of doctor treating: when a sour gasoline is shaken with doctor solution the lead mercaptide formed is able to remove quantitatively all oxidizing material such as peroxides from the gasoline. The result is that when a sour gasoline is doctor treated, one not only removes mercaptans but peroxides as well. The effect of shaking a sour gasoline with doctor solution on peroxide removal is shown as follows:

	Before Shaking	After Shaking
Mercaptan sulfur, gms/100 cc	0.0036	0.0030
Peroxide No.	0.29	0.01

To show the effect of removing peroxides on rate of sweetening, a sour thermal gasoline was doctor-treated to remove all mercaptans and all peroxides. Normal butyl mercaptan was then added to the doctor-sweetened gasoline. When this gasoline was stored in absence of caustic, an extremely slow rate of mercaptan disappearance and practically no peroxide formation was noticed.

When only mercaptans were removed from the original gasoline (by extraction with alcoholic caustic) and the same amount of normal butyl mercaptan added as before, mercaptans disappeared at a much faster rate and peroxide formation was much higher. These data show that the removal of all oxidizing material, such as peroxides, from the gasoline before the start of inhibitor sweetening greatly slows down the rate of sweetening.

One would also predict from the scheme shown in the table that, as inhibitor concentration is increased, rate of sweetening would increase. This is due to the ability of the inhibitor to react with a gasoline radical to form an inhibitor radical. The inhibitor radical can then abstract hydrogen from a mercaptan to give a mercaptyl radical, RS•. Once the RS• is formed, it can react with itself or add to an olefin, both reactions leading to a disappearance of mercaptans from the gasoline.

Another prediction which fits the facts is that inhibitor is consumed during the inhibitor sweetening process. The last reaction shown in the table shows that the inhibitor radical can be oxidized to the imide form; also that peroxides are formed as inhibitor disappears from the system. We would expect that if inhibitor concentration were increased, more inhibitor radicals would be formed and more inhibitor radicals would be consumed giving rise to a greater formation of peroxides; the experimental data bear this out.

The table showing the proposed mechanism of sweetening, when caustic is absent, also illustrates the mechanism involved when caustic is present.

The scheme proposed for sweetening in presence of caustic is different from that shown for absence of caustic.

First, mercaptans dissolved in caustic are oxidized without formation of peroxides.

Second, in the presence of caustic, hydroperoxides are converted to the negative ion of the hydroperoxide, RCOO-. The negative ion of the hydroperoxide is a stronger oxidizing agent than RCOOH and is able to convert mercaptans to disulfides.

Note that RCOO- is shown as also being present in the gasoline phase. This is because the sodium salt of cumene hydroperoxide is quite soluble in gasoline.

The effect of getting RCOONa in the gasoline phase is to accelerate the

Mechanism of Sweetening

Caustic Absent

Production of Free Radicals:

1. Gasoline radicals
   Gasoline → R• → (with O_2) → ROO•
   ROOH → RO•
2. Inhibitor radicals
   Gasoline radical + H In H → In H•
3. Mercaptyl radicals
   Gasoline radical + RSH → RS•
   Inhibitor radical + RSH → RS•

Mercaptan Disappearance:

RS• + RS• → RSSR
RS• + RCH = CH_2 → RCH — CH_2SR

Peroxide Formation:

ROO• + RSH → RS• + ROOH
ROO• + H In H → In H• + ROOH
ROO• + In H• → Quinone imide + ROOH

Caustic Present

Caustic Phase:

RS- + O_2 → RSSR
RS- + RCOO- → RSSR

Gasoline Phase:

RCOO- + RSH → RSSR
RCOO- + In• → Quinone imide

disappearance of mercaptans in the gasoline phase and also to change the pH.

The effect of changing pH is to make the semiquinone form of the inhibitor unstable. The semiquinone form of phenylene diamine is stable only in the pH range of 3 to 6. In the presence of RCOO-, the semiquinone is easily converted to the imide.

A review of the data supporting the mechanism for sweetening in presence of caustic is now presented.

According to the scheme shown, mercaptans disappear in the caustic phase without formation of peroxides. This was borne out by experiments in which straight run gasoline was stored over caustic: sweetening took place without peroxides being formed.

This was also true for a certain thermal gasoline that had been doctor-treated and normal butyl mercaptan then added. Without using any agitation, mercaptans disappeared from the gasoline and from the caustic without peroxides being formed.

This was not true for a more reactive thermal gasoline; peroxides were formed before the normal butyl mercaptan had a chance to go into the caustic phase.

All our data suggest that peroxide formation in inhibitor sweetening is largely determined by the type of gasoline and especially by the amount of mercaptans that are not extracted by caustic.

The last reaction in the table shows how inhibitor disappears from the system. Note that it is the inhibitor radical rather than the inhibitor molecule which is converted to the quinone imide.

The inhibitor molecule is stable to oxidation as long as no oxidation of the gasoline takes place. For example, when all the mercaptans are extracted from light catalytic gasoline and the gasoline stored over caustic, there is no appreciable formation of peroxides and there is no disappearance of inhibitor. This means that the reduced form of the inhibitor is stable in the presence of caustic and air.

However, when mercaptans are not extracted and the gasoline is allowed to undergo inhibitor sweetening in presence of caustic, a definite disappearance of inhibitor takes place. Once the gasoline is sweet, very little further decrease in inhibitor content takes place even though peroxide content may be quite high.

This suggests that it is the semiquinone radicals that are formed during inhibitor sweetening that are unstable in the presence of caustic and are easily oxidized by the negative ion of the hydroperoxide. The reduced form of the inhibitor is not easily subject to oxidation by either peroxides or by the negative ion of the hydroperoxide.

A striking demonstration of the effect of inhibitor sweetening on inhibitor disappearance was provided by an experiment in which a sour gasoline was inhibited with only one lb. of inhibitor per 1000 bbl. and stored in presence of caustic. After sweetening took place, the gasoline behaved as though no inhibitor was present: peroxide number rose to 630.

The data suggest that the oxidation of a gasoline leads to a disappearance of phenylene diamine inhibitor that is related to the amount of oxidation that has taken place. This is true for sweetening in the presence and also in the absence of caustic. This leads us to believe that the semiquinone radical is easily oxidized to the quinone imide form by the ROO• radical and especially by the negative ion of the hydroperoxide.

In regard to the effect of inhibitor concentration on rate of sweetening when caustic is present, the data show that when the gasoline undergoing sweetening is very reactive, that is, forms peroxides easily, sweetening takes place rapidly and the effect of inhibitor concentration on rate of sweetening is of minor importance.

How to improve inhibitor sweetening. The normal procedure of caustic washing an inhibited gasoline and then allowing the gasoline to stand in a storage tank until sweet is a poor way of conducting inhibitor sweetening. Sweetening takes place in the gasoline phase, and as already shown, this leads to peroxide formation. In addition to this, sweetening time can be quite long because sweetening is much slower in absence of caustic and also because there may not be sufficient oxygen present to carry out the sweetening reaction.

To carry out the sweetening reaction in as short a time as possible and to obtain optimum product quality, one should follow this procedure:

Inject air while gasoline and caustic are kept intimately mixed, and provide sufficient contact time of caustic with gasoline to allow sweetening to occur rapidly. There is a limit to how far the peroxide content can be lowered by this method; because most gasolines contain a considerable amount of mercaptans that are difficult to extract and in addition, some of the gasoline peroxides are too unreactive; that is, they will not react with mercaptans in the presence of caustic.

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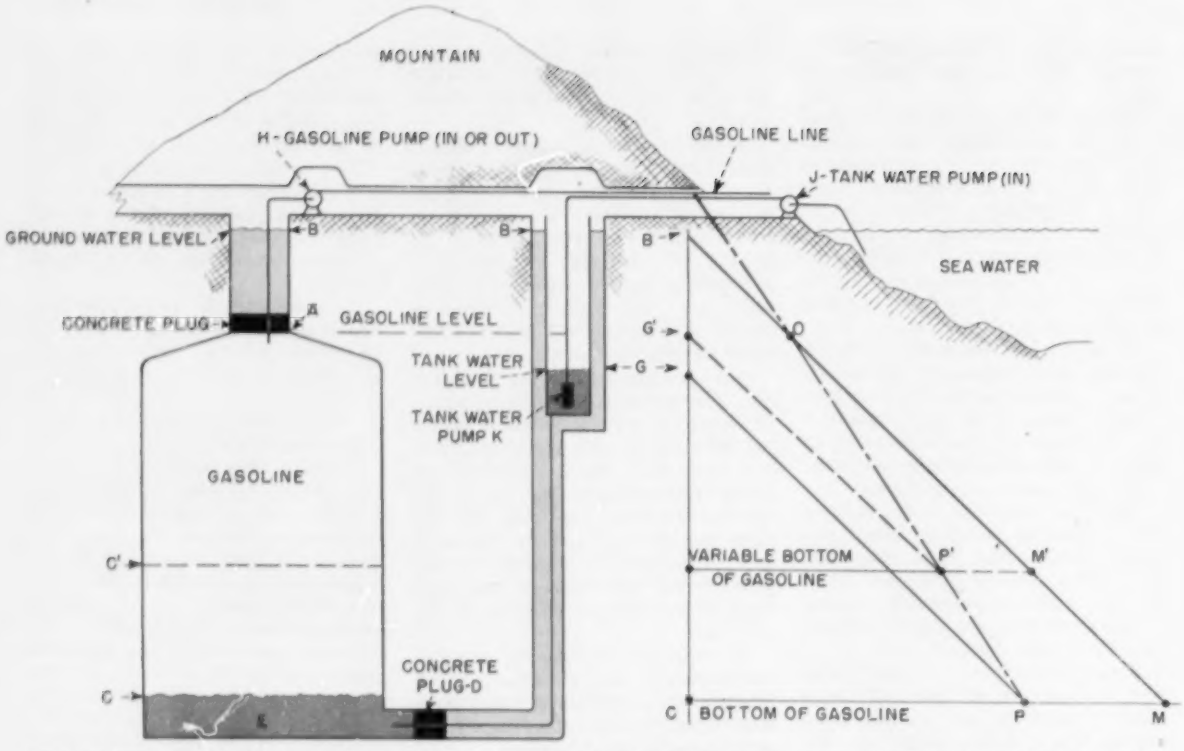
Meet the Authors

Dr. Rampino

Mr. Gorham

Louis D. Rampino, senior research chemist at the Tide Water Associated Oil Co. Avon refinery, Associated, Calif., received his Ph.D. at Fordham University in 1941. He then became associated with the Manhattan Project at Princeton University. In 1943, Dr. Rampino joined Shell Development Co. at Emeryville, Calif., as a group leader on studies of cracking catalysts. He joined Tide Water in 1946, where he has been concerned with gasolines. He is a member of the American Chemical Society, American Institute of Chemists, and Sigma Xi.

Milton J. Gorham, likewise a senior research chemist for Tide Water Associated at the Avon refinery, also joined the company in 1946. He received a Bachelor of Chemistry degree in 1943 from the University of Minnesota, then worked briefly for Sharples Chemical Co. and spent two years in the U.S. Navy before coming to Tide Water Associated. Mr. Gorham is a member of the American Chemical Society.



HOW IT WORKS—cross-sectional diagram of Swedish underground gasoline storage system. See text for detailed description

Underground Gasoline Storage

A new and successful system developed and used in Sweden, and how it works

A NEW system for storing gasoline or oil underground, said to cut annual maintenance costs to 30 or 40% of those of conventional surface tanks, has been developed and put into commercial use recently in Sweden.

As illustrated in the diagram above showing a gasoline storage tank, the system is based on the use of water as a sealing agent against evaporation. The underground cavity can either be blasted out of the solid rock—which adds materially to the initial cost—or use can be made of abandoned mines. In the present commercial installation in Sweden—one tank is approximately 188,000 bbl. and the other is about 375,000 bbl.—an abandoned feldspar mine was used.

Total installed cost for the "Viaco" tank, as the Swedish development is called, ranges from $3.18/bbl. of capacity for tanks up to about 250,000 bbl. to $2.22/bbl. for tanks above that size. This is based on the use of an old mine, and includes all pumps, piping, accessory tanks, etc.

These costs are higher than those for conventional above-ground steel tanks, but lower than those for systems the Swedes have been using for sub-surface storage: i.e., steel or concrete tanks placed in the rock.

The big savings are reported to be made in the lower annual costs. For gasoline storage, it was said these tanks cost 30 to 40% of what conventional surface type tanks cost, mainly because of the reduction in evaporation losses.

Among other advantages cited were:

1—Unlimited storage periods.

2—No losses from leakage.

3—No tank up-keep—painting, etc.

4—Bomb, fire, and explosion proofness.

The Viaco system was developed by Mr. Harold Edholm, purchasing director of the Swedish State Power Board, and is being licensed and built commercially by Svenska Vaeg Aktiebolaget, a Stockholm company. The system for heavier oils was developed shortly after World War II and was adapted for gasoline in 1951.

Key to both types of system is in the use of the water as a hermetic sealing agent. Extra precautions are necessary with gasoline to prevent evaporation. Gasoline storage must be filled completely at all times, whereas oil systems can have a head of air.

The gasoline, or the oil, is pumped directly into the hole. Oil rests on an adjustable bed of water and is prevented from leaking out by the pressure of the surrounding sub-soil water. A prerequisite is that the cavern be situated below the upper level of the

sub-soil water and that the water have a sufficient pressure.

Details of the method for gasoline storage systems are shown in the diagram. A concrete plug, *A*, in the neck of the tank is located well below the ground water level, *B*. The actual level of ground water can be seen at all times in this open hole.

For all practical purposes, the ground water level can be considered invariable—and it also can be assumed to be at sea level, although it may actually be higher. The distance from ground water level *B* to the bottom of the gasoline *C* represents the pressure of the ground water on the gasoline. The bottom of the gasoline is variable, as illustrated by the dotted line *C'*. Top level of the gasoline is a constant—that is, it is always filled up to the concrete plug.

The bottom of the tank is sealed off with another concrete plug at *D*. Through this plug is a pipe which connects the tank water *E* with the control tank *F*. This control tank is a concrete tank surrounded by ground water. The pipe connecting it with the main gasoline storage tank runs through a shaft filled with ground water. This shaft is about four to six square yards in cross-sectional area. It is the one used for carrying out the rock blasted from the main gasoline chamber (either in the case of old mines or in new blasting).

The controlling factor in the system is the water level at *G* (this varies as illustrated by the dotted line at *G'*). The distance from this water level to the bottom level of gasoline represents the pressure inside the main storage chamber. As long as this level *G* is lower than the ground water level *B*, the pressure inside the tank is lower than ground water pressure: and no gasoline can leak out.

When gasoline is pumped out, water is pumped into the tank at the same rate. Gasoline pump *H* and incoming water pump *J* must therefore operate simultaneously and at the same rate (about 800 to 1700 gpm.).

Likewise, when gasoline is being pumped into the tank, the outgoing water pump at *K* (underwater pump) moves water out at the same rate. Pump *K* is underwater, at the bottom of the control tank, because it is a suction pump.

Besides this pump at *K*, there is a smaller water pump with a capacity of 35 to 40 gpm. intended to remove the water that leaks into the gasoline tank. This water leaks in from all sides, descends through the gasoline layer, and eventually into the other tank water at *E*. An automatic pressure switch starts the small pump when too much water has leaked into the tank, thus keeping the pressure constant.

ACTUAL UNDERGROUND CAVERNS look more like this than theoretical shape shown in the diagram

The pressure vector at the right of the schematic in the same drawing will help explain the interaction of water levels. The letters correspond with the letters at the left in the schematic. The 45° line, representing ground water specific gravity, remains constant: and the vertical line for the levels remains constant.

The gasoline specific gravity line, *OP*, deflects from the ground water line at a specific gravity ratio of 0.72. Point *P* where this line meets the bottom gasoline level *C*, marks the ratio between gasoline pressure and ground water pressure. Line *CPM* represents the actual ground water pressure, and line *CP* represents gasoline pressure. Gasoline pressure is the same as tank water pressure, and the specific gravity of tank water is of course the same as that of the ground water.

Therefore, a 45° line representing specific gravity is drawn from the known point *P*, and it cuts the vertical line at *G*, which is the tank water level. As point *C* moves to *C'*, the ratio of points *C'P'M'* is the same as those of *CPM*, and known point *P'* determines the new water level at *G'*. When *C* reaches the same level as *O*, the top of the gasoline level, it means the tank is empty and the pressure inside is equal to the pressure outside. Also, the control tank water level then equals ground water level.

The only preparations for the tank are fitting it with concrete plugs in the neck and in the bottom tunnel, with gasoline piping through the upper plug, with water piping through the lower plug, and the control tank and pumping system. There is no preparation necessary of the inside surface of the rock chamber.

The concrete plug, which is cast into the neck, has dimensions dependent upon the cross-section of the neck. It is usually about 10 ft. in diameter by 20 to 40 inches in thickness.

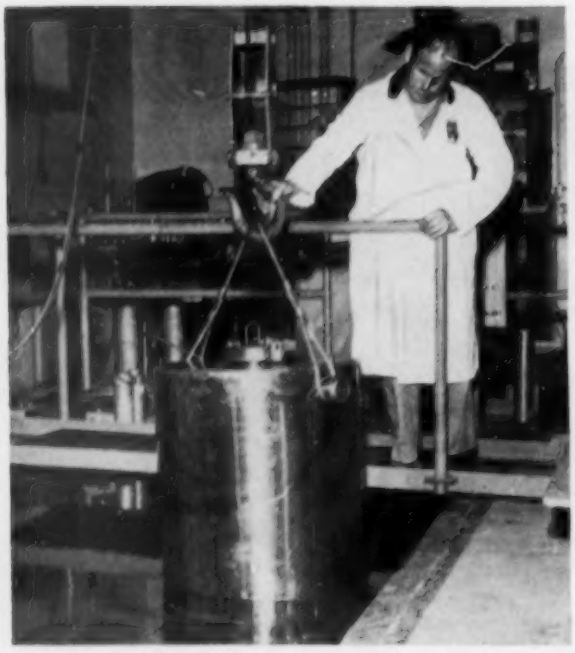
The transfer pumps and water pumps, as described above, have varying capacities. There are three pumps: (1) gasoline pump, (2) incoming water pump, located near the sea, and (3) discharge pump for tank water, located at the bottom of the control tank.

The gasoline can apparently be stored indefinitely. It holds up very well during storage. In fact, its color improves. The accompanying table shows results during an experimental run of some 16 months.

Effects of Underground Storage on Gasoline Properties

Properties	Storage time, months			
	0	3.2	9	16
Specific gravity, @ 20° C.	0.726	0.726	0.725	0.725
Color, Lovibond 18*	2.25	1.25	0.75	0.75
Resin, mg./100 ml.	0.8	1.5	0.6	1.4
Peroxide count	—	—	0.2	0.12
Sulfur, wt.-%	0.057	—	0.051	0.001
Water, wt.-%	0.002	0.001	0.000	0.001
Octane number	70	70	70	70

* Color scale is one used by Swedish refiners. Low end of scale is upper end of quality.



1—Cobalt pipe inside its three-ton lead container is removed from Brookhaven's "swimming pool" reactor. It has been in a "hot box" receiving radiation for 2½ years and now is ready for use in Esso's research studies

2—Truck carrying the radioactive pipe in its lead container crosses the George Washington Bridge across Hudson River, on the way from Brookhaven laboratories on Long Island to Esso research center in Linden, N. J.

A Progress Report on... **The Study**

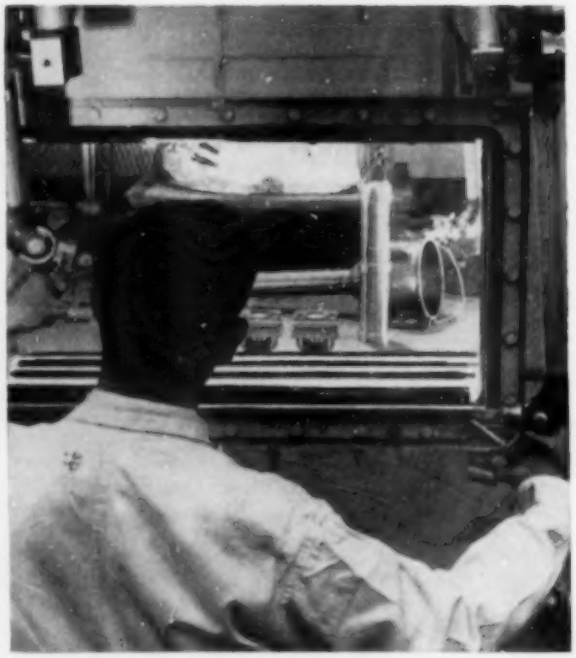
ALMOST three years ago a 13-inch length of 2-in. cobalt pipe was put into the atomic reactor at Brookhaven National Laboratories, Upton, Long Island, N. Y.

Last spring, after more than 2½ years of bombardment, the pipe came out of the reactor. It had a radioactive strength of about 3500 curies. By comparison, the total world supply of refined radium, a naturally radioactive element, represents an estimated 2400 curies.

This piece of cobalt pipe is the heart of the $1,000,000, five-year project undertaken by Esso Research and Engineering Co. to discover peace-time uses for atomic energy in the field of processing. (See "Atomic Energy a Process Tool?" PETROLEUM PROCESSING, Jan., 1955, pp. 43-45).

Specific purpose of the studies will be to see what the pipe's gamma rays will do, chemically, to oil materials. Fuels, lubricants, and petrochemicals today are the result of chemical reactions.

The pictures on these two pages show the job involved in getting the pipe—in its three-ton lead shield—from Brookhaven to the Esso research center's new atomic laboratory in Linden, N. J.



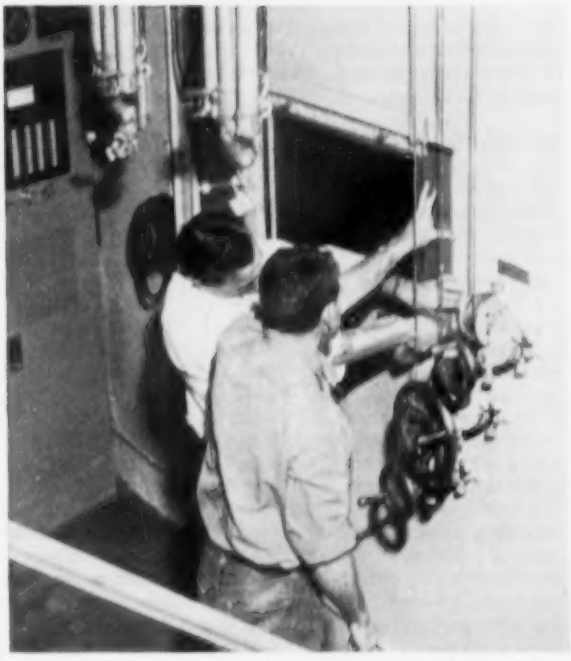
5—Out of the container and inside the cave, the pipe must now be handled with mechanical hands by remote control. Operator controls all activities inside the cave while making observations through three-foot-thick window

3—Dwarfed by the huge crane, the radioactive cobalt pipe "package" is being unloaded from the truck for removal to its permanent home in the new laboratory designed for finding uses for atomic energy in processing

4—Almost at its final destination, the cobalt pipe package is wheeled into the "cave" room of Esso's new laboratory, the first such privately financed atomic radiation facility in the petroleum industry

# of Radiation as a Process Tool

6—Another view, from the inside looking out, showing the mechanical hands at work moving the radioactive cobalt pipe in the cave. This picture was made with a "dummy" pipe for demonstration purposes



7—Safety first and always is the constant watchword. Operators are pasting strip of X-ray film on outer walls of cave room. Film is used to keep a continuous check on presence of radiation in operators' area

A PANEL OF PROCESSING TECHNOLOGISTS* who bring you with the aid of a wire recorder . . .

Technical Tips on

Petroleum Processing Problems

What has been found to be the best lubricant for the compression cylinders of catalytic reformer recycle gas compressors?

What is the minimum volume of oil necessary for satisfactory cylinder lubrication on cat reformer recycle compressors?

Brown: The first question refers to the recycle gas compressor only. In the recent Ultraformer start-up that we have had at the Pan-Am Southern here at El Dorado, the problem of catalyst contamination from lube oils was paramount in our minds. When we requested recommendations from engine manufacturers, they recommended that we start with a 30 drops per minute per cylinder and then, at the first chance, take the valve caps out and see if that was still sufficient. Then, reduce to 25, then to 20, and so on.

We did that and got to 20, and that is about the point at which we are operating now. In addition to this being a problem even at 20, we have developed a new oil—I don't think it has been announced and I'm not making a particular plug for it—but it has only 5% lubricant, as far as lubricants go. This is 5% sperm oil and an "Indipol" product, which is a polybutene. The real advantage in this is that it evaporates or breaks down to butane at about 700°, so that you will only have about 5% of the lubricant actually affecting the catalyst. The 20 drops per minute feed rate is still the rate that we're using this oil.

Eckhouse: This is a case where an ounce of prevention is worth a pound of cure. We have developed a non-regenerative reforming process. We are able to keep it non-regenerative by keeping such things as lube oil out of our catalyst cases. We have done that on virtually all of our Platforming units by using carbon pistons and carbon rings. We have had excellent life on these; practically no trouble at all. You not only eliminate the problem of catalyst contamination, but also eliminate a maintenance problem and an operating problem of continually watching and adjusting the lube oil flow.

Heike: We have a Platformer operating at our Ft. Worth plant for a little under three years. It has carbon pistons and has been doing a very satisfactory job as far as lubrication is concerned on compressor cylinders. Actually, every 18 months we change the packing on the compressors. Every other shutdown we take one and then the other.

The only maintenance we have had to do so far, other than cleaning the valves, is to repack and put new rods in. The only disadvantage I can think of with the non-lubricated cylinders is the fact that the packing tends to pick up solids. Some of these soluble chlorides that form eventually end up in the packing and score the rods. But we feel that a pair of rods every 18 months is not very expensive.

Maddox (Blaw-Knox): It is the recommendation of a lot of compressor people that about one pint of lube oil is needed per million square feet of cylinder area swept. On that basis, it looks like it would take a period of almost two years, possibly, to build up any quantity of oil which might even be noticeable in a catalytic reformer. As yet, I have not heard of anyone who uses lubricated-type cylinders having any difficulty resulting from their lubrication.

What has been the experience on charging high sulfur content feeds to catalytic reformer reactors?

Norris: I can't really say too much about this yet. We have four of our Houdry reformers running. Of those, we have one which has a feedstock containing enough sulfur to be worth

* Left to right: Parker, Eckhouse, Norris, Rippie, Heike, Brown, Feasel, Gearhart, and Wilson. (Edwards was not present for this picture.)

considering as a problem. The unit is prepared to handle a good bit more sulfur. The way it is handled is in the feed treating.

Gas production from the high-pressure separator—in excess of recycle requirements—is bled into a guard-case. Feed plus some of this gas passes over a catalyst at a very high space rate—a very small reactor, moderate conditions. Sulfur removal is, say, 95%. As I say, we have only the one unit yet with enough sulfur to be a problem and solving it in that way has been very satisfactory to this point.

Eckhouse: Sulfur is a temporary poison on platinum catalysts. It is simply a matter of taking the sulfur out if it is high enough. There are various ways of doing it, the method used depending on what the level is—the quantity of sulfur in the feed. I know some California stocks which we have run are over 1% sulfur. As long as the unit is properly designed, however, there is no problem whatsoever. It's just a question of taking them out.

Of course, a guard chamber won't remove sulfur compounds, really, it will simply convert them to H_2S, and you must have a stripper after the guard chamber to remove the H_2S.

What is known about de-ethanizer plugging caused by ammonium salts and what means were used to eliminate the problem? This is a hot bottoms absorber operating as a de-ethanizer.

What has been the nature and extent of hold-up, priming and carryover difficulties in operating low-temperature, low-pressure absorber strippers? This is an absorber-stripper operating with refrigeration at 70° F. top temperature, 145° F. reboiler temperature and 90 psig. The absorber-stripper is part of a Fluid cracker gas plant.

To what are difficulties of the above nature ascribed? Is salt deposition a factor? Have the salts been definitely identified and what are they?

Assuming that soluble salts have precipitated under low-temperature conditions, has anyone set up a water-washing program? What are the details as to quantity, frequency and point of introduction?

Is absorber-stripper operation a critical one? That is, can the tower become literally packed or flooded with too low a top temperature for a given reboiler temperature?

Eckhouse: That type of column really can be considered as a fractionating column. The feed is at the middle, there is a reboiler to produce stripping vapors, and reflux to the column really is lean oil which is fed into the top of the absorber. We used that column, I believe, years ago, in the design of UOP gas plants. We no longer do it because of the problems which are described in the questions—the priming and so forth.

What apparently happens is this. If water is fed to the column, such a low-temperature is maintained on top that the water can't get out. There is a reboiler on the bottom so it can't get out there, either. As a result, water builds up as an internal recycle in the column. Obviously, the thing to do is to put some water draws on the column and remove the water. The alternative is to cut the column in two, making the absorber and stripper two separate columns.

We would recommend splitting it into two columns if possible, You then have an absorber which operates as a de-ethanizer, plus a stripper.

The other problem, the salt deposition, probably results from charging feedstocks containing nitrogen, sulfur or chlorine, or any combination of those. The solution is what is being done in quite a few gas plants: that is, water-washing the feed to the gas plant. This will remove the salts and the water is removed from the column by the water-draws.

Another difficulty with this type of column is the job which it has to do if a separation is attempted, among other things, between H_2S and propane. It won't do this very well. As a result H_2S winds up in the LPG. With a high-pressure de-ethanizing absorber, such as UOP installs, the H_2S-C_3 split is virtually complete. Also potential problems later downstream are eliminated, such as in the depropanizer and debutanizer.

The ammonium salts which are formed are volatile. They behave very much like the water internally in the column; they volatize at the bottom and condense at the top, so they have no way of getting out. Some are volatile enough to go overhead and some will come out at the bottom, but there always will be some left behind in the column. So you shut down the column to prove to your management or superintendent that the column is plugged with salt, and as you shut down the column is steamed out. This volatilizes all the salt, and when you go in to look at the column, it is clean. But the salts were there when you were operating the column, in all probability.

We know pretty well now what feeds will definitely produce the salts and can design for them.

From floor: **What if it's CO_2?**

Eckhouse: That would be water soluble too, if you were to water-wash the feed. Another question among those just asked is rather interesting.

Ten Experts Answer Your Processing Questions

This article is the sixth and last in a series which began with the March issue, providing answers from 10 authorities in their fields on a complete range of petroleum processing problems.

Like a similar series we were pleased to present last year, this material is based on a popular day-long session at a regional meeting of the Western Petroleum Refiners Ass'n. in El Dorado, October, 1954. It was obtained by means of a wire recorder by PETROLEUM PROCESSING's editors.

Wide experience was represented by the panel of authorities—five from refining companies and five from suppliers or engineering firms. The moderator was E. A. Heike, chief engineer, Premier Oil Refining Co., Ft. Worth, Texas, who filled the same role in the panel the year before.

The refining group included: J. M. Brown, assistant manager of operations, Pan-Am Southern Corp., El Dorado, Ark.; R. E. Feasel, supervisor of fuels manufacturing, Deep Rock Oil Corp., Cushing, Okla.; J. A. Gearhart, process engineer, American Liberty Oil Co., Mt. Pleasant, Texas; and R. S. Wilson, chief chemist, Lion Oil Co., El Dorado, Ark.

The engineering group consisted of: J. G. Eckhouse, sales engineer, Universal Oil Products Co., Des Plaines, Ill.; O. D. Edwards, sales engineer, Perco Division, Phillips Petroleum Co., Bartlesville, Okla.; D. E. Norris, commercial development engineer, Houdry Process Corp., Philadelphia, Penna.; F. D. Parker, western manager, Blaw-Knox Co., Tulsa, Okla.; and C. W. Rippie, president, Electric Process Co., Summit, N. J.

It is the one asking whether the operation of this column is critical or not. If you do a heat balance on the absorber-stripper column you will find that roughly 80 or 90% of the heat input to the reboiler just goes to sensible heat in the bottoms stream leaving the column. The balance produces stripper vapors. You can see, therefore, that in any conventional means of controlling heat input to that reboiler, a small percentagewise change in heat input will make a considerable change in production of stripper vapors. The column is very hard to control for that reason, and conventional means of heat control cannot be used on the column and really do a good job. The best thing to do is just not to put in that type of column.

Gearhart: It seems to me that the question is: what has this group found to be the best means of temperature control where you have the absorber-stripper combination in one tower?

Eckhouse: The best way, probably, is to put a flow meter in the vapor line going back to the column, going to a flow control on the heat input to the reboiler. That way, you can control your heat input and get constant vapor production.

From floor: In our case we control the bottom temperature leaving the column.

What are the best types of tubes for use in a surface condenser cooled with high velocity salt water?

Edwards: If H_2S is present, use aluminum-brass, and if H_2S is not present use 90% copper-10% nickel with high iron. By "high iron" I think is meant 0.2%. I know that Admiralty is used, but where the breaking point is with respect to velocity I don't recall.

Has anyone experienced a steam or hydrocarbon explosion in a vacuum tower on or after a shutdown or during a startup? If so, was it a steam or hydrocarbon explosion? If a hydrocarbon explosion, what may have been the circumstances and theory of ignition?

Eckhouse: I know of one case some years ago in a vacuum tower. The unit had been shut down and steamed out. Apparently they thought it was completely free of hydrocarbon. When the vacuum was broken, air was pulled in. Apparently there was enough hydrocarbon present to explode.

What we normally do to avoid that is to put a bleeder ahead of the jets and break the vacuum under a steam pressure, so no air could be pulled in when the vacuum was broken. In other words, steam the tower under vacuum and then bleed steam in; opening the steam bleeder wide and just gradually break the vacuum with steam.

From floor: **What are the problems of arsenic poisoning in cat reforming?**

Eckhouse: I think arsenic poisoning in reforming has been given unnecessary emphasis—it has been dragged out, solved, re-solved, and discussed at practically every meeting and discussion on reforming.

We all know that in every catalytic process there are poisons. If they were all as easy to detect and remove as arsenic, there certainly would be no problems in catalytic processing. Arsenic will react with platinum, tie it up so that the activity of the catalyst will decline. The solution is very simple: remove the arsenic from the feed.

About 10% of the units that we have licensed have encountered arsenic in the feed. Of those, to my knowledge, in only one of them was it ever a serious problem and that was on the first one. We detected it within a week, solved the problem, and we haven't had it since.

From floor: **How did you solve it?**

Eckhouse: Arsenic is very easy to remove from naphthas. I think you will find some references in the literature.

In those units in which we have Unifining as a feed pretreatment, the arsenic is completely removed. Unifining is a joint-licensed process of the Union Oil Co. of California and Universal Oil Products Co.

Norris (asked to comment on butane dehydrogenation): There seems to be considerable interest at the present time in butane dehydrogenation. I don't know how many of you have a little excess butane around which does not have a great deal of value.

We have been making extensive studies recently on the problem of upgrading normal butane; dehydrogenation of n-butane to make butadiene, or to butylenes to start chemical syntheses, or to alkylate, maybe. A 2¢ butylene for alkylate may be a very reasonable starting point.

We can charge n-butane through a Houdry dehydrogenation process for a yield of butadiene in excess of 52% or so, or we can make it into butylenes with a yield of 65 to 70%. I don't know whether this is of interest to you or not; just raising the question. Anybody that would like to ask any specific questions about the subject, I will try to answer them.

Eckhouse: What does it cost you to make butylenes per gallon?

Norris: Starting with about a 5¢ n-butane or mixed butane feed, we can make butadiene for about 9.88¢/lb.—roughly 50¢/gal. The butylene is less expensive, because, of course, the yield is higher and it can be a somewhat cheaper plant (and recovery is simpler). To make butadiene is a vacuum operation, and to make butylenes can be atmospheric or even positive pressure. The equilibrium reaction favors the butadiene if you lower the pressure. That isn't a precise answer because that's with a 5¢ feed.

From floor: You say that's 9.88¢ per lb. to make?

Norris: Of butadiene *recovered.*

From floor: That's pretty expensive.

Norris: No, that's the point. You are *recovering* the butadiene. It goes through an extraction plant, which adds several cents to that. I'm sorry to have been misleading on that. I didn't give a clear enough answer.

You can probably come out with butylene for . . . let me state it in a slightly different way. I think that with 4¢ n-butane you can make alkylate for about 13¢, of course assuming that you don't have to buy i-butane at about 7 or 8¢/gal. If you come in with a common butane stream, with enough isobutane, and all your butanes are charged in at around 4¢, you can make alkylate for something approximating 13¢/gal. With n-butane at 4¢/gal., butylene would cost 13.7¢. If butadiene were also produced, the cost of butylene might be several cents per gallon less.

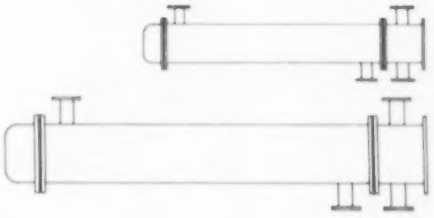
From floor: **Will the butylenes from the butylene plant be pure enough, with respect to butadiene, to charge into an alkylation unit?**

Norris: No. Probably you would want to do one of two things. Either recover butadiene from such a plant or go through a selective hydrogenation step. That's dependent, of course, on the economics of acid usage in the alkylation unit.

Trufin Opportunities
Number 8 of a series.

4 REASONS WHY WOLVERINE TRUFIN* SHOULD BE USED FOR DEPROPANIZER HEAT EXCHANGERS

1. *Extra Efficiency* — Wolverine Trufin Type S/T condenser tube has integral fins — provides more than 2½ times the outside surface of prime surface tubing. You get *more heat transfer per foot of tube with Trufin!*



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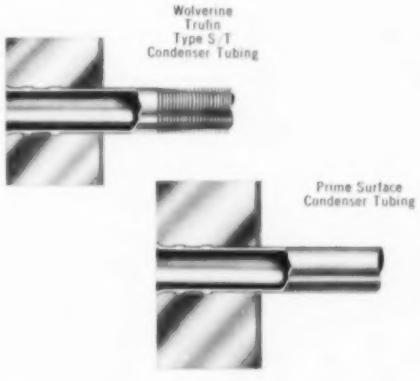

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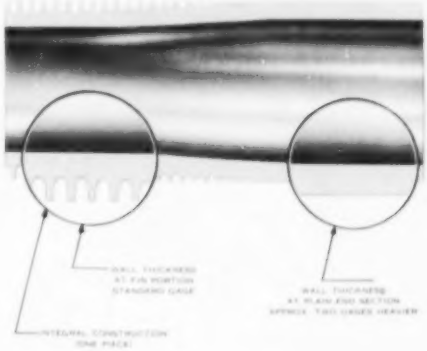

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Q. Will this field service help us in other ways?

A. Definitely! The group is composed of tube technicians—each a counsellor in corrosion, fabrication, you name it! They solve tough problems like yours every day.

Q. Run down the list of your condenser tube products again.

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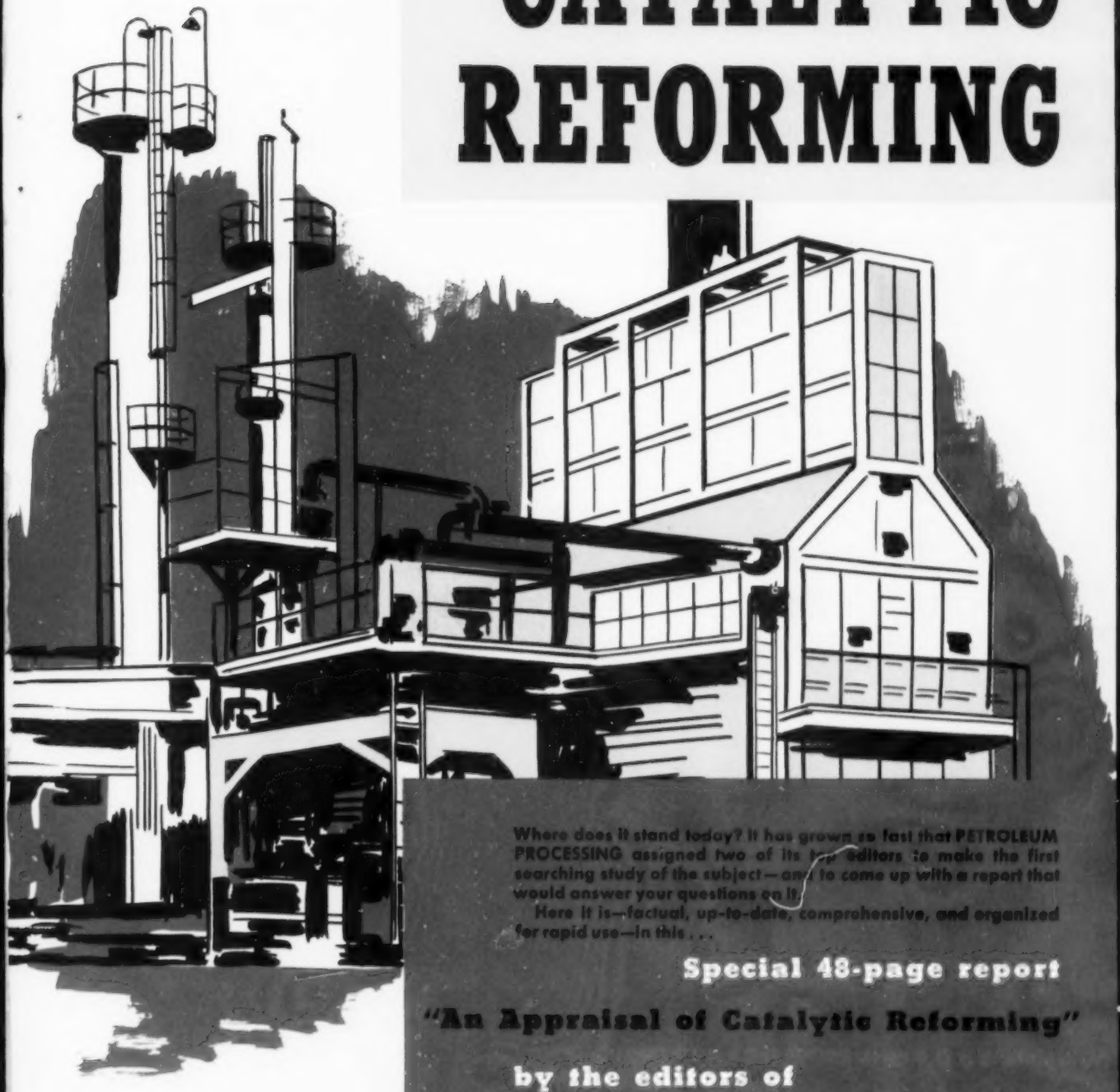
IT'S TIME TO TAKE A NEW LOOK AT

CATALYTIC REFORMING



Where does it stand today? It has grown so fast that PETROLEUM PROCESSING assigned two of its top editors to make the first searching study of the subject—and to come up with a report that would answer your questions on it.

Here it is—factual, up-to-date, comprehensive, and organized for rapid use—in this . . .

Special 48-page report

"An Appraisal of Catalytic Reforming"

by the editors of

Petroleum Processing

If you're concerned with long-range planning, it will give you ideas on how the process can fit into your program.

If you have to evaluate the processes, it will help you select the ones best suited for your needs.

If you have to operate or maintain a new unit, it will tell you who has a similar installation and can give you first hand advice.

What You'll Find in This

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Where Are We Going with Catalytic Reforming?

- **How much capacity we can expect to have**
- **What sort of products it will be used for**

By V. B. GUTHRIE, Associate Editor

It's even bigger than the experts thought it was.

Last year we were talking in terms of 500,000 b/d of catalytic reformer capacity in this country and Canada by the end of 1955. Only a few months ago we were estimating installed capacity at 750,000 b/d.

But today, according to the first complete census of catalytic reformers installed, under construction and planned, just finished by PETROLEUM PROCESSING:

- Total charge capacity now in operation is 914,100 b/d.
- Under construction or definitely planned is another 381,000 b/d.
- Total capacity estimated by the end of 1956 is 1,295,100 b/d.

This rapid growth—from virtually zero b/d only five years ago—has taken the industry by surprise. For example: one large engineering firm made a projection less than two years ago of this growth through the year 1960; this firm has just recently up-dated that study from 1960 to "1956," and has started out all over again on a new survey of the outlook for 1960.

The rapid acceptance of catalytic reforming as a basic processing tool is particularly significant when you consider that the first modern catalytic reforming process was announced only six years ago. Today, 10 competitive processes are available to refiners, on reasonable license terms, and construction costs are relatively low. By comparison, catalytic cracking was first installed in 1936, and it was not until 1946 that charge capacity reached 1,000,000 b/d.

This growth in catalytic reforming not only emphasizes the importance of the process itself to refiners; it also brings into sharper focus related developments where progress is likely to be at an equally accelerated pace.

Along with its census of catalytic reforming units in the U.S. and Canada, PETROLEUM PROCESSING has also undertaken to survey and appraise some of the factors which will have to do with the continued expansion of this processing technique. Any such study logically breaks down into three major fields:

1—Catalytic reforming as a source of motor fuels.

- How much above the present 96-98 research octane fuel will it be possible for refiners to go with catalytic reforming, including process improvements now in sight?
- What will the likely markets be in the next five and ten years for motor gasolines above 100 research octane? In this period will the advent of gas turbine engines for powering automobiles have any noticeable effect on the motor gasoline markets?
- What range of charge stocks, outside of straight-run gasoline and naphthas, will it be economically practical for refiners to process by cathalytic reforming?

2—Catalytic reforming as a source of aromatics.

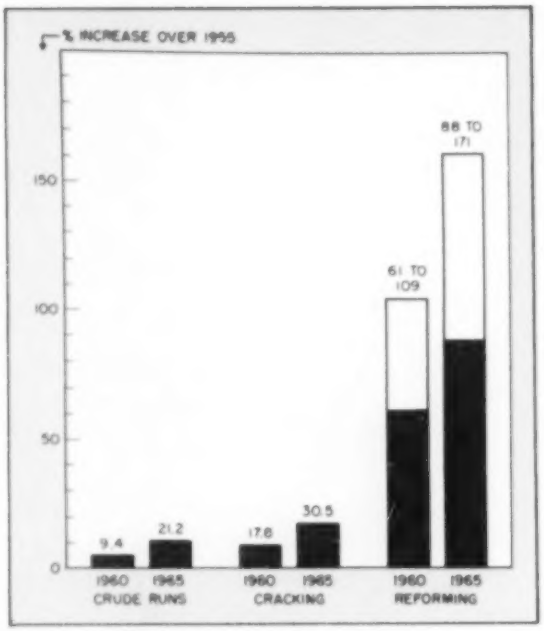
- What will be the volume growth in the demands for the aromatic petrochemicals—benzene, toluene, xylene—which can be recovered from catalytic reformates?

3—Catalytic reforming as a source of by-product hydrogen.

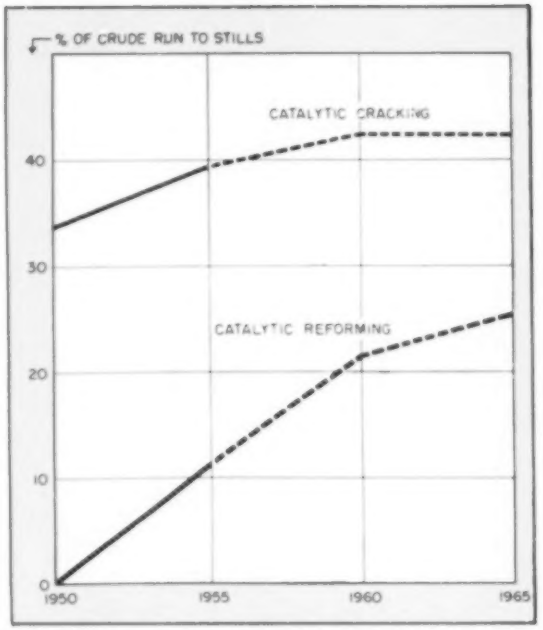
- What will be the most economic utilization of the low cost hydrogen which is becoming increasingly available from catalytic reformers—and most of which has been burned as fuel?

In the following pages are presented the results of the studies by PETROLEUM PROCESSING's editors on these and other points having to do with the future use of catalytic reforming.

An Appraisal of Catalytic Reforming as a Source of MOTOR FUELS



CATALYTIC REFORMING IS GROWING faster than cracking or overall refining capacity, and . . .



ITS SHARE OF CRUDE RUNS IS GROWING FASTER than is that of catalytic cracking

FOUR MAJOR factors must be considered in making an appraisal of catalytic reforming as a source of motor fuel.

1 – The extent of catalytic reforming today – its ratio to total refining capacity – and its potential for the next 10 years.

2 – The way in which reforming will help meet the growing demands for more gasoline of higher octane numbers.

3 – The possibilities of using feed stocks other than those in current use.

4 – Process improvements or modifications here now or on the way which might change the outlook.

CAPACITY

There is today, and will continue to be, enough catalytic reforming capacity in this country. The total available for reforming for motor fuel manufacture at the end of this year will be approximately 960,000 b/d. By comparison, catalytic cracking capacity at year's end will be about 3,350,000 b/d and overall crude capacity will be 8,500,000. In other words, reforming will account for 11.3% of crude runs, and cracking will account for 39.5%.

Future trends are illustrated in the charts and table. Estimates vary on the exact figures, but broadly speaking: in 1960, reforming will account for 16.7 to 21.5% of crude runs, and cracking 42.5%. Ten years hence, in 1965, reforming's share will have reached 17.5 to 25.2%, and cracking's portion will have held at 42.5% of crude runs.

The capacity estimates themselves range in the following way from low to high: 1960, reforming, 1,550,000 to 2,000,000 b/d; and 1965, between 1,800,000 and 2,600,000 b/d.

"The extremely rapid expansion of catalytic reforming is evident," stated A. L. Lyman, president of California Research Corp. in a paper presented at the 20th Midyear Meeting of the Refining Division, American Petroleum Institute, in St. Louis this past spring. "Two or three years ago, it was hardly a factor in gasoline manufacture. It seems probable that, by up-grading both straight-run and

cracked stocks, catalytic reforming capacity in the U. S. may soon surpass catalytic cracking capacity for gasoline production."

The rise in catalytic reforming for motor fuel production can be expected to continue until the "saturation point" is reached for reforming those straight-run and naphtha feed stocks which are economically available. Most authorities believe this will be before 1960.

At that point it is estimated the capacity will be 1,700,000 to 1,800,000 b/d. This is based upon an estimated 20% of virgin feed stocks being available from the crudes which will be processed in the next five years. A somewhat lower estimate by some companies puts the installed reformer capacity at nearer to 1,400,000 b/d when the saturation point is reached.

In either case, it is then likely that the rate of expansion of catalytic reforming capacity will slow down to parallel the growth in general refining capacity, and for two reasons:

First: by that time the premium motor fuel market will begin to call for higher octane gasoline than the 98-99 octane leaded reformate now regarded as the maximum obtainable from presently installed reforming units. Gasolines of over 100 research number octane can be turned out of reformers, but more efficient processes will likely be developed.

Secondly: further increases in overall reforming capacity will call for a wider range of feed materials than the virgin gasolines and naphthas now being used. Such new materials might include coker and cracked gasoline, and perhaps natural gasoline and other materials.

OCTANE RACE

The levelling off in reforming capacity as a result at least in part of the continuous octane race has already been discussed briefly.

"Maximum utilization of catalytic reforming, and cracking, by refiners will permit production of gasolines of high octane value, but perhaps not high enough," it was brought out by Mr. Lyman in his API paper.

"We can reach an average level of 98-99 for average premium grade by utilizing catalytic cracking and reforming to the fullest extent now considered possible. Perhaps improved catalysts will permit us to exceed the 100 octane level before 1965. It seems probable, however, that new processes will have to be developed to meet the future high octane levels beyond the ability of catalytic reforming.

"Furthermore, it is not probable that this upward octane trend will reverse or be superseded by some new automotive development during the next few years. Jet engines, several years after appearing in significant numbers, have only now apparently stabilized aviation gasoline quantity and quality trends. Replacement of the piston-powered automotive engine by some comparable development, in significant numbers, is not expected at least in the immediate future."

Mr. Lyman predicted some commercial fuels of 102 research octane number by 1965, based on estimated requirements to satisfy 90% of the new model cars on the road by that time. However, he stated, fuels of around 97-98 octane would satisfy the needs of 50% of these future cars.

FEED STOCKS

Although the saturation point for use of virgin gasolines and naphthas for reformer feed will not be reached until nearly 1960, much study is already being given to the wider range of hydrocarbon materials that may become economically suitable for feed stocks.

The principal limiting factor in the consideration of lighter materials will be the degree of improvement that can be obtained through reforming. Among the heavier materials, a principal limiting factor will be the higher boiling range of such feeds, since reforming might possibly step up the boiling points to beyond those in motor gasoline specifications.

Materials under study now as supplemental feed stocks to reformers include: coker gasoline, cracked gasoline, high boiling point gasoline now going into motor fuel, pentane for isomerization, natural high sulfur stocks following desulfurization, and natural gasoline.

Natural gasoline is believed less likely to benefit from catalytic reforming than the so-called "distillate gasolines" produced from cycling plants. This is because the portion of the natural gasoline which can be up-graded may range from as low as 15 to as high as 40 vol-%, depending upon the individual stock.

Proportionately more of the product of the cycling plants – often called "heavy natural" – is susceptible to improvement by reforming than is natural gasoline. The reformed total blend – leaded – can in many cases be sold directly as regular grade motor fuel. If it were severely reformed, some of the cycling plant material could be sold as premium grade gasoline.

PROCESSES

Some technological improvements have already been announced by some of reforming process licensors aimed at producing reformate of 95 to over 100 research octane. Expected improvements will include:

Desulfurization and other feed preparation steps.

Single-stage and more severe reforming.

Combining aromatics and reformate production.

Reforming and then further treatment of the reformate to improve octane.

Refiners also have other strings for their bow than reforming per se for raising octane quality of their gasolines. The volume of tetraethyl lead being used in premium gasoline is steadily increasing. By 1960, it seems apparent that refiners will be using up the 3 cc./gal. legal limit. Desulfurization of the gasoline feed stocks will increase the lead susceptibility of the finished product and allow some further increase in octane value over that with untreated stocks.

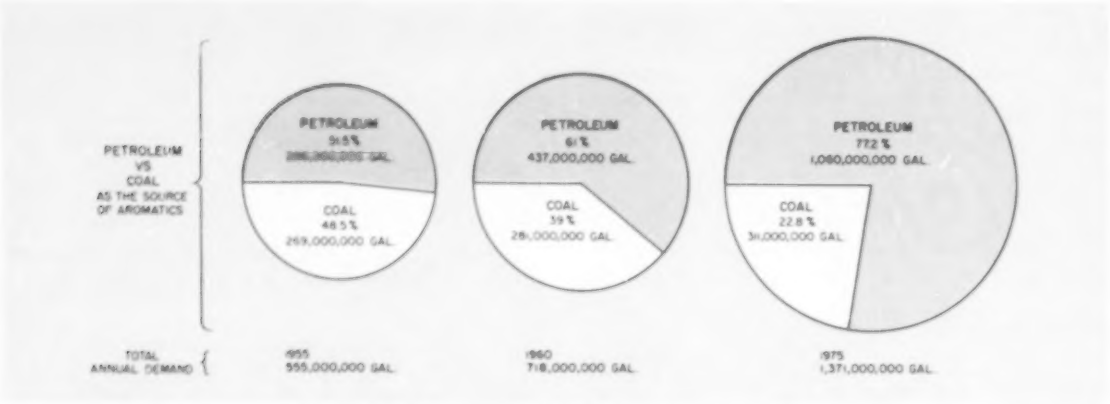
It is safe to say that, with the accelerated pace of technological improvements in the catalytic reforming process as evidenced today and with other means at their disposal, refiners will continue to supply the higher octane value gasolines in sufficient quantity and in advance of the time they are actually needed by the higher compression engine new model cars.

A Bigger Share of Crude Runs for Catalytic Reforming

(1000 b/d average)

	Crude Runs to Stills	Cracking Catalytic Cracking	Cracking % of Crude Runs	Reforming Catalytic Reforming	Reforming % of Crude Runs
1955	8,500	3,350	39.5	960	11.3
1960	9,300	3,950	42.5	1,550 to 2,000	16.7 to 21.5
1960 increase over 1955.	800	600	—	590 to 1,040	—
percentage.	9.4	17.8	—	61.6 to 109	—
1965 increase over 1955.	1,800	1,020	—	840 to 1,640	—
percentage.	21.2	30.5	—	88 to 171	—
1965	10,300	4,370	42.5	1,800 to 2,600	17.5 to 25.5

An Appraisal of Catalytic Reforming as a Source of AROMATICS



PETROLEUM'S GROWING SHARE of the aromatics market

ONE OF THE BEAUTIES of a catalytic reforming unit from the refiner's viewpoint is its versatility. You can use it to make gasoline, or—with proper selection of feed stock, minor adjustment of operating conditions, and suitable recovery equipment—you can turn out aromatics.

Even though the volume of aromatics now being produced from petroleum is relatively small in comparison to usual refining industry thinking, it's still appreciable. Output this year is expected to be 286-million gal., or close to 20,000 b/d.

FUTURE DEMAND

The outlook for future demand is even brighter. As indicated in the chart above, total demand for the three major aromatics—benzene, toluene, xylene—from all sources is expected to nearly triple during the next two decades.

That's only part of the picture, however. Since aromatics from coal are pretty much a by-product operation, output from this source isn't likely to increase very much except as the coking of coal increases. And since coke is tied directly to steel, a fairly stable, mature industry, there's likely to be only a slow, normal growth in coke production.

The upshot: Aromatics from coal haven't been and aren't likely to grow at anywhere near the spectacularly rapid rate at which the burgeoning chemical industry is mushrooming the demand for aromatics. While demand over the next 20 years is growing by 150%, output from coal will go up only 16% (269-million gal. in 1955 to 311-million in 1975).

That's where petroleum comes in. Since aromatics from catalytic reforming are a primary—not a by-product—operation, their output can be adjusted to fit demand. And nearly all of the increase in demand is expected to be met by petroleum, which will provide an estimated 286-million gal. this year, and 1,060-million in 1975—a 270% increase.

Let's put it another way. Total annual aromatic demand is expected to increase by 816-million gal. over this 20-year period. Output from coal will provide only 42-million gal. of this additional amount; petroleum will supply the rest—or 774-million gal.

Current and projected demand for the individual aromatics, and the amounts expected to be supplied by petroleum and coal, are given in the following table:

	Benzene	Toluene	Xylene	Total
	(all figures in million gal. per year)			
1955 Demand	390	68	97	555
Supplied by coal	211	42	16	269
Supplied by petroleum	179	26	81	286
1960 Demand	492	87	139	718
Supplied by coal	220	44	17	281
Supplied by petroleum	272	43	122	437
1975 Demand	902	146	323	1371
Supplied by coal	243	49	19	311
Supplied by petroleum	659	97	304	1060

Source: "Joint Symposium on Future of Aromatic Hydrocarbons," ACS, April 4 to 7, 1955.

Benzene is considered the most attractive of the aromatics because of the diversity of its uses and its volume demand. It represents about 70% of total aromatics output, and is not likely to lose this dominant position.

Toluene has the least potential demand for it today being less than 20% of the demand for benzene. The outlook

is for only a doubling of this demand by 1975.

Xylene probably has the most unpredictable outlook—and the most exciting. A 230% increase in demand is seen by 1975.

PRESENT SUPPLIERS

There are presently 20 catalytic reformers in operation in the U.S. for the production of aromatics from petroleum, according to PETROLEUM PROCESSING's Census of Catalytic Reforming. Their total charge capacity, which can be directed in whole or in part to aromatics production, is 181,200 b/d. These plants are listed below.

A charge capacity 181,200 b/d doesn't mean that much aromatic product, however. Depending on the composition of its feed stock, a reformer will yield roughly only about 50% aromatics. And few if any units are operated totally for aromatics production. They may be run on a blocked-out operation for limited production of aromatics as feed stock is accumulated.

COMPETITION and PROBLEMS

There'll be competition for the use of the aromatics from petroleum, however. Benzene, toluene and xylene have high octane blending values, and are therefore valuable gasoline components in their own rights. The refiner who elects to use his reformer to make aromatics may find that he is having trouble in meeting the quality requirements of his motor gasolines—particularly if the trend to higher compression ratio engines continues. He may need his entire output of reformate just for gasoline.

Consequently, some authorities see an economic battle between chemical and fuel requirements for reformer output. In many instances, the refiner's problem will not be one of disposing of surplus reformer capacity, but rather of selecting the operation that will make the best economic use of his facilities. Those refiners blessed with feed stocks containing relatively high naphthenic contents will have some advantage—at least until some new processing technique is developed.

Manufacturing costs and marketing difficulties are also problems which the refiner contemplating getting into aromatics must consider. Gallon for gallon, it will cost him more to make aromatics than gasoline, since he must install recovery and purification equipment, and additional storage facilities. When it comes to markets, he won't have a ready-made one as he does for gasoline; he'll have to plan to develop his own outlets, or make a deal with an established firm to handle his sales and distribution.

Despite all these pitfalls, more refiners will undoubtedly start planning to make aromatics if the 270% growth in petroleum's share of the market begins to materialize as predicted. They'll find the competition intense, and in a field in which they will have only limited experience.

But they'll still have their ace-in-the-hole. If the market for aromatics goes sour, they can juggle a few valves and switch to gasoline instead.

Where Petrochemical Aromatics Are Being Made

Company and Location	Reformer Type	Reformer Capacity, b/sd	Aromatics Recovered	Aromatics recovery process used
American Oil Co., Texas City, Texas	Ultraformer	21,000	benzene, toluene, mixed xylenes	Shell Extractive Distillation
Atlas Processing Co., Shreveport, La.	Platformer	4,400	benzene	Shell Extractive Distillation
Continental Oil Co., Lakes Charles, La.	Platformer	6,000	benzene, toluene	Modified SO_2 Extraction
Continental Oil Co., Ponca City, Okla.	Platformer	5,000	benzene, toluene	Shell Extractive Distillation
Cosden Petroleum Corp., Big Spring, Texas	Platformer	4,000	benzene, toluene, mixed xylenes, para-xylene	Udex
Eastern States Chemical Co., Houston, Texas	Platformer	7,000	benzene and aromatic solvents	Udex
Great Southern Chemical Corp., Corpus Christi, Texas	Platformer	6,000	benzene, toluene, mixed xylenes	Udex
Humble Oil & Refining Co., Baytown, Texas	Ultraformer	20,000	toluene, para-xylene, aromatic solvents	Modified SO_2 Extraction
Petrocarbon Chemicals, Inc., Irving, Texas	Houdriformer	1,000	heavy aromatic solvents	Arosorb
Pure Oil Co., Toledo, Ohio	Fixed-Bed Hydroformer	5,500	toluene, mixed xylenes, aromatic fractions	Shell Extractive Distillation
Roosevelt Oil & Refining Co., Mt. Pleasant, Mich.	Platformer	2,000	benzene, toluene	Udex
Shell Oil Co., Wilmington/Dominguez, Calif.	Platformer	3,500	toluene, mixed xylenes	Shell Extractive Distillation
Shell Oil Co., Wood River, Ill.	Platformer	3,800	toluene, mixed xylenes, commercial solvents	Shell Extractive Distillation
Shell Oil Co., Houston, Texas	Platformer	15,000	benzene, toluene	Shell Extractive Distillation
Sinclair Refining Co., Marcus Hook, Pa.	Sinclair-Baker	16,000	toluene, para-xylene, mixed xylenes	Udex
Standard Oil Co. (Calif.), El Segundo, Calif.	Platformer	11,000	benzene, mixed xylenes	Shell Extractive Distillation
Standard Oil Co. (Calif.), Richmond, Calif.	Fixed-Bed Hydroformer	14,000	benzene, toluene, mixed xylenes	(not disclosed)
Standard Oil Co. (Ind.), Whiting, Ind.	Fixed-Bed Hydroformer	13,000	benzene, toluene, mixed xylenes	Udex
Sun Oil Co., Marcus Hook, Pa.	Houdriformer	14,000	benzene, toluene, mixed xylenes	Udex
Tide Water Associated Oil Co., Avon, Calif.	Platformer	10,000	aviation blending stock	Modified SO_2 Extraction

An Appraisal of Catalytic Reforming as a Source of HYDROGEN

CATALYTIC REFORMING is providing refiners with large volumes of by-product hydrogen for which three general classes of use are shaping up:

- **Within the Refinery:**

1–Desulfurizing and improving the qualities of feed stocks and eventually of heavy residues and crude oils.

2–Upgrading a wide range of finished products to lower the sulfur content and improve storage stability, color, odor and other qualities.

3–Processing with hydrogen to manufacture aviation gasoline and motor gasoline components.

- **In Petrochemical Operations:**

1–Synthesizing ammonia for nitrogenous fertilizer materials and other uses.

2–In conjunction with carbon monoxide in the manufacture of methanol and special alcohols.

3–Reduction of benzene to cyclohexane.

- **In Other Industries:**

1–Hydrogenation of fatty oils to eliminate objectionable acids.

2–As a reducing agent in the manufacture of metal powders.

3–In the small volume manufacture of miscellaneous chemicals.

The by-product hydrogen available today from catalytic reformers in the U.S. and Canada totals close to 500-million cu. ft. daily, and within 10 years will reach well over a billion cu. ft. daily. This volume is impressive, and makes it important for the individual refiner looking into the future to make the most practical and economic disposition of his by-product hydrogen.

IN THE REFINERY

Hydrogen-consuming refining processes have been known for many years, but it is only within the past few that the hydrogen has been available in the required volumes – as a result of the rapid installation of catalytic reformers. Several commercial processes for treating feed stocks and for upgrading finished products have been developed.

The present use with feed stocks is principally in the mild hydrogenation of catalytic reforming feed to desulfurize, to hydrogenate the olefins and to remove other contaminants. Research and pilot plant work by oil companies have demonstrated that more severe hydrogenation can be used to desulfurize and improve heavy residues and even the high sulfur crudes refiners are processing today. The economic incentives for treating crudes and heavy feed stocks include reducing refinery operating and maintenance costs as well as improving product quality. These are potentially large enough that this development in hydrogen treating will be rapidly pushed to the commercial stage.

The upgrading of finished products is the second principal application of mild hydrogen treating in refineries. Products susceptible to improvement include motor fuels, range oils, solvent naphthas, diesel fuels, and even lubricating oils and waxes. Product characteristics are upgraded in many ways. Mild hydrogenation of some cracked gasolines can improve their storage stability without loss of octane value. Cetane number of cracked diesel fuels can be increased, with other improvements. Kerosine and light distillates can be given better burning qualities. Color of lube oil stocks can be improved.

Hydrogen processes to manufacture aviation gasoline were developed during World War II. The base stocks of 100-octane gasoline were catalytically cracked naphthas and selected virgin naphthas or their equivalent produced by destructive dehydrogenation. Blending agents included isooctane from the hydrogenation of butene compounds. These methods have been improved since the war and today both high-pressure and low-pressure hydrogenation processes are available for making high-octane avgas base stocks. In the isomerization of normal pentane and hexane fractions for motor fuel components, hydrogen is used for minimizing undesirable side reactions.

A new use for by-product hydrogen in refining is the catalytic hydrocracking process announced by Socony Mobil Oil Co. for producing jet fuels. Product yields are increased and combustion performance, heat content per pound, and hydrogen content are said to be greatly improved over conventional fuels.

IN PETROCHEMICALS

In the manufacture of petrochemicals the largest use of hydrogen is in the manufacture of ammonia for nitrogen fertilizers. Of 52 synthetic ammonia plants in the country, five are located in refineries which report catalytic reforming installations.

The production of fixed nitrogen from ammonia produced in the U.S. from all sources has grown from 1,560,000 tons in 1950-51 to an estimated 2,470,000 tons in 1954-55, the impetus being primarily in the demand for the fixed nitrogen used in fertilizer.

"We expect this demand to continue to expand rapidly," Robert L. James, Arthur D. Little, Inc., Cambridge, Mass., told the annual meeting of the American Petroleum Institute last November. "However, if the plant capacity to produce ammonia – the primary raw materials for making useful nitrogenous fertilizer materials – continues to increase at the rate of the past three years, substantial over-

supply with its attendant adverse economic effects is likely to happen."

"New ammonia plants for the next several years cannot be predicated on the need for additional nitrogen," he said. "Instead, most new ammonia projects not involving captive consumption must be justified on process cost advantages, cheaper raw materials, freight savings resulting from location, or other relative economic advantages which prospective new producers may offer."

Ammonia plants based on catalytic reformer hydrogen are cheaper to build than those based on natural gas, fuel oil, or coke, it was brought out, because the hydrogen producing section of the conventional ammonia plant is eliminated. Another advantage is that the hydrogen is delivered at high pressure, –200 to 700 psi and the ammonia plant is spared a part of the cost of compressor investment and compression energy.

With this cost advantage, stated Mr. James, it is likely that some new plants using catalytic reformer hydrogen will be built, irrespective of demand-capacity relationships, to exploit their economic advantages.

Also in the petrochemical field, relatively small but growing markets for hydrogen exist in the manufacture of methanol and special alcohols. The hydrogen is used in association with carbon monoxide. At present, catalytic reformer hydrogen in this operation is at a disadvantage to the hydrogen made by the partial oxidation of natural gas or by the water gas reaction. Improvements in the present technology may overcome this disadvantage, some authorities believe.

IN OTHER INDUSTRIES

Other uses for off-reformer hydrogen in industrial operations are varied but their volume is expected to remain small. In chemical manufacturing, the hydrogenation of fatty oils provides an outlet for hydrogen, the purpose being to eliminate objectionable acids and convert the liquid oils to solids. High purity hydrogen is required.

One potential market for hydrogen is in metallurgy, particularly as a reducing agent in the manufacture of metal powders and metal hydrides. Powder metallurgy is expected to grow and refineries located near such operations may find limited markets for their off-reformer hydrogen.

WHICH TO CHOOSE

The most practical and economic outlet for the refiner's by-product hydrogen seems destined to be its use within the refinery in processing and in treating products. This will be the case regardless of how large the volume of available hydrogen becomes as catalytic reforming expands. In fact, some authorities believe the refiners' use of hydrogen will become so great that they will eventually become consumers of this material beyond what is available to them from reforming.

The factors that throw the economic balance in favor of the use of hydrogen within the refinery include the fact that it can be applied in most desulfurizing and upgrading operations just as it comes from the reformer. In many uses in the chemical field it would have to be brought to higher purity. Another reason is that the volume of hydrogen available will be in proportion to the volume of the refiners' feedstocks and finished products to be treated. Some of the other uses for hydrogen, as in synthesizing ammonia, are seasonal in character.

Most important, however, is the fact that the use of hydrogen by the refiner in desulfurizing and upgrading his own feedstocks and products represents an enormous potential market even today, many times greater than all outside uses. By 1965 the estimated total demand for petroleum of 11,000,000 bbls. will mean a potential outlet for hydrogen within the refinery more than a third larger than it is today.

The potentialities in hydrogen treating as a part of refining operations can be glimpsed from data taken from PETROLEUM PROCESSING's Census of Catalytic Reforming. Total charge capacity today is 914,100 b/d. Production of hydrogen from catalytic reforming varies from 400 to 800 cu. ft. or higher per barrel of gasoline or naphtha charge. Taking 500 cu. ft. per barrel as an average production, as cited by some authorities, the total available off-reformer hydrogen today is around 455,000,000 cu. ft. per day. If catalytic reforming in the U.S. reaches the projected 2,-600,-000 bbls. charge capacity by 1965, total available hydrogen would amount to 1,300,000,000 cu. ft. daily.

On the other side of the picture: It has been estimated that 90% of off-reformer hydrogen is available for other processing uses, also that on the average 200 cu. ft. of hydrogen is consumed per barrel of oil hydrogenated. Using these estimates, some 410,000,000 cu. ft. of hydrogen can be considered today as potentially available for treating and this volume would hydrogenate over 2,000,000 b/d. By 1965 hydrogen will be available for treating over 5,800,-000 bbls.

This figure of hydrogenation capacity, large as it is, is well under the estimated demand for light petroleum products in 1965, which is between 7.5 and 8,000,000 b/d. Part of this capacity will also be used for desulfurizing and treating feed stocks, perhaps even crude, as well as hydrogenating finished products.

So it seems likely that, regardless of how fast and far catalytic reforming is expanded, refiners will find ample uses for their by-product hydrogen in improving their own operations and products.

On the next four pages: Census of Reformers ▸

Following that: Detailed Process Descriptions ▸

Census of Catalytic Reforming

CATALYTIC REFORMING units with a total charge capacity of 914,100 b/d are now in operation in the U.S. and Canada, according to the first Census of Catalytic Reforming, just completed last month by PETROLEUM PROCESSING. In addition, 388,300 b/d of new capacity is under construction or planned.

This is the most rapid application of any general refining process in the industry's history, since the first modern catalytic reforming process was announced only six years ago. All indications are that this rate of growth will continue for the next few years. By 1965, PETROLEUM PROCESSING's editors forecast, total charge capacity will reach 2,500,000 b/d.

In the U.S. there are 116 units now in operation (885,700 b/d capacity), and 53 more which are on the way with announced capacities totaling 344,700 b/d. In addition, 12 units are reported under consideration, with no capacities given.

In Canada there are 8 units operating (28,400 b/d capacity) and another 9 on the way (43,600 b/d capacity).

Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
ARKANSAS			
Pan-Am Southern Corp.			
El Dorado	Ultraformer	6,600	
CALIFORNIA			
Bankline Oil Co.			
Bakersfield	*	—	Process under study
Calstate Refining Co.			
Long Beach	Hyperformer	1,100	Hydrogen for desulfurization
Douglas Oil Co. of Calif.			
Bakersfield	Catformer	2,500	
General Petroleum Corp.			
Torrance	Thermofor Catalytic Reformer	19,000	
Mohawk Petroleum Corp.			
Bakersfield	Platformer	2,500	
Richfield Oil Corp.			
Watson	Sinclair-Baker*	17,000	Richfield's own design. Hydrogen to be used for desulfurization. Completion scheduled for summer 1956.
Rothschild Oil Co.			
Sante Fe Springs	Platformer	1,000	
Seaside Oil Co.			
Ventura	Hyperformer*	1,200	
Shell Oil Co.			
Martinez	Platformer	5,500	Hydrogen for ammonia
Wilmington	Platformer	3,500	Reformate used alternately for gasoline and aromatics. Part of hydrogen for desulfurization
Standard Oil Co. of Calif.			
El Segundo	Platformer	11,000	Reformate alternately for gasoline and aromatics
El Segundo	Platformer	22,000	
Richmond	Fixed Bed Hydroformer	14,000	Reformate alternately for gasoline aromatics
Richmond	Platformer	22,000	
The Texas Co.			
Wilmington	Platformer	10,000	Part of hydrogen for desulfurization
Tide Water Associated Oil Co.			
Avon	Platformer	10,000	Hydrogen for desulfurization
Union Oil Co. of Calif.			
Rodeo (Oleum refinery)	Platformer	14,750	Hydrogen for desulfurization
Wilshire Oil Co.			
Norwalk	Platformer*	5,000	Hydrogen to be for desulfurization
COLORADO			
Skelly Oil Co.			
Denver	Platformer*	650	
DELAWARE			
Tide Water Associated Oil Co.			
Delaware City	*	—	Process unannounced

Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
ILLINOIS			
Clark Oil & Refining Corp.			
Blue Island	Platformer	5,500	
Ohio Oil Co.			
Robinson	Houdriformer	8,300	
Pana Refining Co.			
Pana	Platformer	750	
Shell Oil Co.			
Wood River	Platformer	3,800	Reformate for aromatics. Part of hydrogen for desulfurization
Wood River	Platformer	16,000	
Socony Mobil Oil Co.			
East St. Louis	Sovaformer*	—	In planning stage only
Standard Oil Co. (Ind.)			
Wood River	Ultraformer	9,000	
The Texas Co.			
Lawrenceville	Platformer	13,500	
Lockport	Platformer*	10,900	
INDIANA			
Cities Service Oil Co.			
East Chicago	Fluid Hydroformer	12,780	
Indiana Farm Bureau Coop. Assn.			
Mt. Vernon	Platformer*	3,000	Hydrogen to be for desulfurization
R. J. Oil & Refining Co.			
Princeton	Platformer	600	
Rock Island Refining Corp.			
Rock Island	Platformer	2,400	
Sinclair Refining Co.			
East Chicago	Sinclair-Baker	16,000	Hydrogen for sale
Socony Mobil Oil Co.			
East Chicago	Sovaformer*	9,000	Under construction
Standard Oil Co. (Ind.)			
Whiting	Fixed Bed Hydroformer	13,000	Reformate alternately for gasoline and aromatics
Whiting	Orthoformer	25,000	Hydrogen for fuel, desulfurization and ammonia.
KANSAS			
Anderson-Prichard Oil Corp.			
Arkansas City	Platformer*	4,000	Completion scheduled for Oct. 1955
Cooperative Refinery Assn.			
Coffeyville	Platformer*	5,000	Hydrogen to be for desulfurization
Derby Oil Co.			
Wichita	Ultraformer*	2,500	Under construction. Completion estimated Jan. 1, 1956. Capacity can be increased to 4000 b/sd
El Dorado Refining Co.			
El Dorado	Platformer*	2,500	Being designed.
National Cooperative Refinery Assn.			
McPherson	Platformer*		Has fast tax write-off certificate

Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
Phillips Petroleum Co.			
Kansas City	Fixed Bed Platinum*	16,000	Under construction. Estimated completion spring 1956
Skelly Oil Co.			
El Dorado	Platformer	7,500	
Socony Mobil Oil Co.			
Augusta	Sovaformer	3,000	
Vickers Petroleum Co.			
Potwin	*	—	
KENTUCKY			
Ashland Oil & Refining Co.			
Catlettsburg	Houdriformer	6,000	Part of hydrogen for desulfurization
LOUISIANA			
Atlas Processing Co.			
Shreveport	Platformer	4,400	
Shreveport	Platformer*	3,600	Under construction.
Bay Petroleum Corp.			
Chalmette	Platformer	1,500	
Chalmette	Platformer*	5,900	Plans being prepared for this second unit.
Canal Refining Co.			
Church Point	Catformer	750	
Cities Service Refining Corp.			
Lake Charles	Fluid Hydroformer	17,250	
Continental Oil Co.			
Lake Charles	Platformer	6,000	Reformate alternately for gasoline and aromatics
Esso Standard Oil Co.			
Baton Rouge	Fluid Hydroformer	27,800	
Ingram Oil & Refining Co.			
Chalmette	"	3,000	Type of unit undecided
International Petroleum & Chemical Exchange			
Lake Charles	"	—	Certificate of necessity
Pan-Am Southern Corp.			
Destrehan	Fluid Hydroformer	2,650	
Southwest Gas Producing Co.			
Dubach	*	1,800	Company has fast tax write-off approval.
MARYLAND			
Esso Standard Oil Co.			
Baltimore	Fixed bed Platinum type	3,000	Part of hydrogen for desulfurization
MASSACHUSETTS			
Esso Standard Oil Co.			
Everett	Fluid Hydroformer	7,200*	Planned for completion in 1956
MICHIGAN			
Aurora Gasoline Co.			
Detroit	Platformer	7,000	Desulfurization unit for part of hydrogen, under construction
Elsie	Platformer	1,500	
Muskegon	Platformer	2,200	Desulfurization unit for part of hydrogen, under construction
Leonard Refineries, Inc.			
Alma	Ultraformer*	2,400	Under construction. Completion Oct. 1956. Can be increased to 3,500 b/sd with added heater and larger pumps. Hydrogen for desulfurization
Mid-West Refineries, Inc.			
Alma	Platformer	2,000	
Naph-Sol Refining Co.			
Muskegon	Platformer	1,000	
Petroleum Specialties, Inc.			
Flatrock	Platformer	900	
Roosevelt Oil & Refining Corp.			
Mt. Pleasant	Platformer	2,000	Reformate alternately for aromatics and gasoline. 80% of hydrogen for desulfurization
Socony Mobil Oil Co.			
Trenton	Sovaformer*	9,000	Under construction
MINNESOTA			
Great Northern Oil Co.			
Pine Bend	Ultraformer*	5,000	Hydrogen for desulfurization
Northwestern Refining Co.			
St. Paul Park	*	4,000	Process not decided on.
MISSISSIPPI			
Paluxy Asphalt Co.			
Yazoo City	*		
MISSOURI			
Standard Oil Co. (Ind.)			
Sugar Creek	Ultraformer	14,000	25% of hydrogen to be used for desulfurization
MONTANA			
Big West Oil Co. of Montana			
Kevin	Platformer*	1,000	Completion scheduled Oct. 1, 1955
Carter Oil Co.			
Billings	Esso Fixed Bed Platinum*	2,500	Completion Jan. 1955. Hydrogen for desulfurization
Continental Oil Co.			
Billings	*	2,000	Type not decided. Hydrogen for desulfurization
Farmers Union Central Exchange			
Laurel	Platformer*	2,500	Hydrogen to be for desulfurization
Union Oil Co. of Calif.			
Cut Bank	Catformer	600	Hydrogen for desulfurization
NEBRASKA			
Cooperative Refinery Assn.			
Scottsbluff	Platformer*	650	To be on stream about Oct. 1955
NEW JERSEY			
California Oil Co.			
Perth Amboy	Platformer	10,700	
Esso Standard Oil Co.			
Linden	Fluid Hydroformer*	19,000	Under construction
Socony Mobil Oil Co.			
Paulsboro	Sovaformer*	20,000	Was scheduled for completion this summer
The Texas Co.			
Westville	Platformer	12,000	Hydrogen used for desulfurization
NEW MEXICO			
Famariss Oil & Refining Co.			
Hobbs	Platformer*	600	Hydrogen to be used for desulfurization
Four States Western Oil Refining Co.			
Farmington	*	500	Estimated completion spring 1956.
Malco Refineries, Inc.			
Prewitt	Catformer	750	
McNutt Oil & Refining Co.			
Brickland	Platformer	600	
NEW YORK			
Socony Mobil Oil Co.			
Brooklyn	Sovaformer*	—	Planning stage only
Buffalo	Sovaformer*	—	Planning stage only

*Under construction or planned

Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
NORTH DAKOTA			
Standard Oil Co. (Ind.)			
Mandan	Ultraformer*	6,000	Completion scheduled for spring of 1956
Williston Basin Refining Co.			
Williston	Catformer	300	
OHIO			
Gulf Oil Corp.			
Toledo	Platformer	10,000	
Cincinnati	Platformer	10,000	
Pure Oil Corp.			
Newark (Heath Refinery)	Sinclair-Baker	3,000	Part of hydrogen for desulfurization
Toledo	Fixed Bed Hydroformer	5,500	Reformate alternately for gasoline and aromatics. Hydrogen for fuel and sale
Standard Oil Co. (Ohio)			
Cleveland (No. 1 refinery)	Ultraformer*	11,000	Completion mid-1956
Lima	Platformer	12,000	
Sun Oil Co.			
Toledo	Platformer	14,000	
OKLAHOMA			
Anderson-Prichard Oil Corp.			
Cyril	Catformer	1,000	
Bell Oil & Gas Co.			
Grandfield	Platformer	1,500	
Champlin Refining Co.			
Enid	Platformer	5,000	
Cities Service Oil Co.			
Ponca City	Rexformer	6,000	In planning stage
Continental Oil Company			
Ponca City	Platformer	5,000	Reformate used simultaneously for gasoline and aromatics
Johnson Oil Refining Co.			
Cleveland	Platformer	1,840	Company is considering Unifining
Midland Cooperatives, Inc.			
Cushing	Platformer*	2,000	
Sunray Mid-Continent Oil Co.			
Duncan	Platformer	5,000	
Tulsa	Catformer	7,500	
The Texas Co.			
Tulsa	Platformer*	9,040	Under construction.
Wilcox Oil Co.			
Bristow	Platformer	1,500	
PENNSYLVANIA			
Atlantic Refining Co.			
Philadelphia	Catformer	15,000	Hydrogen for ammonia
Gulf Oil Corp.			
Philadelphia	Platformer	16,000	
Philadelphia	Platformer*	26,000	
Kendall Refining Co.			
Bradford	Platformer	1,500	
Pennzoil Co.			
Rouseville	Platformer*	2,900	Completion to be in fall
Quaker State Oil Refining Corp.			
Emlenton	Platformer	1,000	
Farmers Valley	Platformer	1,500	
Sinclair Refining Co.			
Marcus Hook	Sinclair-Baker	16,000	Reformate for gasoline and aromatics. Part of hydrogen for sale
Sun Oil Co.			
Marcus Hook	Houdriformer	14,000	Reformate for aromatics. Hydrogen for ammonia
Marcus Hook	Houdriformer	18,000	Hydrogen 80% for ammonia. Balance for desulfurization, fuel, hydrogenation
United Refining Co.			
Warren	Catformer	2,500	Hydrogen for desulfurization
TENNESSEE			
Delta Refining Co.			
Memphis	*	—	
TEXAS			
American Liberty Oil Co.			
Mt. Pleasant	*	—	
American Oil Co.			
Texas City	Fixed Bed Hydroformer	7,500	
Texas City	Ultraformer	21,000	Reformate is used for both gasoline and aromatics
Anderson-Prichard Oil Corp. (Col Tex Rfg. Co.)			
Colorado City	Platformer	1,500	
Atlantic Refining Co.			
Port Arthur	Catformer	7,200	
Avtane Refining Co.			
Freeport	*	2,000	Company has fast tax write-off
Cosden Petroleum Corp.			
Big Spring	Platformer	4,000	Reformate is used alternately for gasoline and aromatics. Will eventually be shifted to 100% aromatics. Unifiner under construction
Big Spring	*	3,900	
Crown Central Petroleum Corp.			
Houston	Houdriformer	5,000	
Danaho Refining Co.			
Pettus	Platformer	1,000	
Delhi-Taylor Oil Corp.			
Corpus Christi	Platformer	6,000	
Delhi-Taylor Oil Corp. & Mayfair Minerals, Inc.			
Port Isabel	Platformer	4,500	
Eastern States Petroleum Co.			
Houston	Platformer	7,000	Reformate is used simultaneously for gasoline and aromatics. Hydrogen for desulfurization
Gladewater Refining Co.			
Gladewater	Catformer	750	
Great Southern Corp.			
Corpus Christi	Platformer	6,000	Reformate is used for gasoline and for aromatics.
Gulf Oil Corp.			
Port Arthur	Platformer	29,000	
Humble Oil & Refining Co.			
Baytown	Ultraformer*	20,000	Under construction. Part of hydrogen is used for desulfurization
Baytown	Ultraformer	20,000	Part of reformate is used for aromatics and other solvents. Part of hydrogen for desulfurization converted Fixed Bed Hydroformer
McBride Oil & Gas Corp.			
LaBlanca	Catformer	750	
McMurrey Refining Co.			
Tyler	Platformer	5,000	
Magnolia Petroleum Co.			
Beaumont	Thermofor Cat. Reformer	19,000	
North American Petroleum Corp.			
Corpus Christi	Catformer*	2,500	In design stages
Onyx Refining Co.			
Abilene	Platformer	650	
Pan American Refining Co.	—	—	Name changed to American Oil Co. See listing above
Panhandle Oil Corp.			
Wichita Falls	*		In planning stage
Petrocarbon Chemicals, Inc.			
Irving	Houdriformer	1,000	Reformate simultaneously for gasoline and aromatics

Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
Phillips Petroleum Co.			
Phillips	Platformer*	16,000	Will be on stream Sept. 1955. Part of hydrogen for desulfurization
Sweeney	Platformer	16,000	
Phillips Petroleum Co. (Natural Gas Dept.)			
Phillips	Platformer	7,000	
Pontiac Refining Corp.			
Corpus Christi	Platformer	6,000	
Premier Oil Refining Co. of Texas			
Fort Worth	Platformer	1,800	
Pure Oil Co. (Smith's Bluff Refinery)			
Nederland	Ultraformer	15,000*	Part of hydrogen to be for desulfurization
Republic Oil Refining Co.			
Texas City	Platformer	5,500	
Shell Oil Co.			
Houston	Platformer	15,000	Reformate alternately for gasoline aromatics
Houston	Platformer*	16,000	Estimated completion Jan. 1956
Sinclair Refining Co.			
Houston	Sinclair-Baker*	24,000	Part of hydrogen to be sold
Skelly Oil Co.			
Longview	Platformer	1,850	
Southwestern Oil & Refining Co.			
Corpus Christi	*	7,125	Type of unit not decided
Standard Oil Co. of Texas			
El Paso	Platformer*	4,300	Under construction
Suntide Refining Co.			
Corpus Christi	*	10,000	No decision on type
Texas City Refining Co. Inc.			
Texas City	*	6,000	No decision on type. Reformate alternately for gasoline and aromatics
The Texas Co.			
Amarillo	Platformer	4,500	Hydrogen to treat reformer feed stocks
El Paso	Platformer	3,500	Hydrogen to treat reformer feed stocks
Port Arthur	Platformer	20,000	Hydrogen to treat reformer feed stocks
Port Arthur	Platformer	20,000	Hydrogen to treat reformer feed stocks
Texas Gas Corp.			
Winnie	Platformer	2,500	
UTAH			
Utah Oil Refining Co.			
Salt Lake City	Ultraformer*	5,000	Completion mid-1956
Western States Refining Co.			
North Salt Lake City	Houdriformer*	1,000	
VIRGINIA			
American Oil Co.			
Yorktown	*	7,500	No decision on type
WASHINGTON			
General Petroleum Corp.			
Ferndale	Sovaformer	6,000	
Shell Oil Co.			
Anacortes	Platformer*	8,000	Estimated completion Sept. 1955. Part of hydrogen to be for desulfurization
WEST VIRGINIA			
Elk Refining Co.			
Falling Rock	Platformer	1,500	Hydrogen used for fuel, but will be for sale also. A 1,000 b/d Unifiner is under construction
Quaker State Oil Refining Corp.			
St. Marys	Platformer	1,000	
WISCONSIN			
Lake Superior Refining Co.			
Superior	Platformer	1,100	
WYOMING			
Frontier Refining Co.			
Cheyenne	Platformer*	2,000	Completion exepected this summer. Hydrogen to be for desulfurization
Husky Oil Co.			
Cody	Catformer	1,000	Hydrogen for desulfurization
Socony Mobil Oil Co.			
Casper	Sovaformer*	—	In planning stage only
Standard Oil Co.			
Casper	Ultraformer	3,750	
The Texas Co.			
Casper	Platformer*	4,800	Completion 1956.

Canada

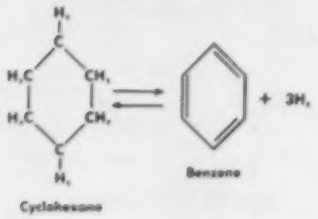
Company & Location	Type of Unit	Charge Capacity b/sd	Remarks
ALBERTA			
Anglo American Exploration Ltd.			
Hartell	Catformer*	1,000	Under construction or in design
British-American Oil Co.			
Calgary	Catformer	2,000	
Imperial Oil Ltd.			
Edmonton	Esso Fixed Bed-Platinum*	2,000	Hydrogen to be for lube oil treating
BRITISH COLUMBIA			
Excelsior Refineries, Ltd.			
Dawson Creek	Houdriformer*	500	Planned
Shell Oil Co. of Canada Ltd.			
Vancouver	Platformer*	3,300	Completion late 1955. Part of hydrogen for desulfurization
Standard Oil Co. of British Columbia			
Vancouver	Platformer*	2,700	
MANITOBA			
Anglo Canadian Oils Ltd.			
Brandon	Platformer*	1,000	
ONTARIO			
Canadian Oil Refineries Ltd. (Sarnia Refinery)			
Corunna	Platformer	3,500	Part of hydrogen for ammonia
Husky Oil & Refining Ltd., Riverlake Division			
Fort William	Catformer	1,000	
Imperial Oil Co.			
Sarnia	*	13,500	Type unannounced. Completion Oct. 1956
Sun Oil Co.			
Sarnia	Houdriformer	3,000	Hydrogen for sale
Trinidad Leaseholds (Canada) Ltd.			
Port Credit	Platformer	2,300	
QUEBEC			
British American Oil Co.			
Montreal East	Catformer*	13,000	Completion late 1955. Reformate used for gasoline. Will eventually also be used for aromatics.
Canadian Petrofina Ltd.			
Pointe aux Trembles	Ultraformer	3,600	Part of hydrogen for desulfurization
McColl-Frontenac Oil Co. Ltd.			
Montreal East	Platformer	12,000	
Shell Oil Co. of Canada			
Montreal East	Platformer*	6,600	Completion mid-1956. Part of hydrogen for desulfurization
SASKATCHEWAN			
Husky Oil & Rfg. Ltd.			
Moose Jaw	Catformer	1,000	Was scheduled for start-up in July. Hydrogen for desulfurization

*Under construction or planned

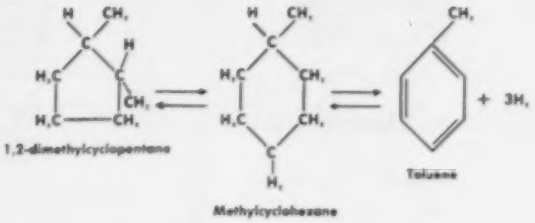
Catalytic Reforming—How It Works

OCTANE IMPROVING REACTIONS

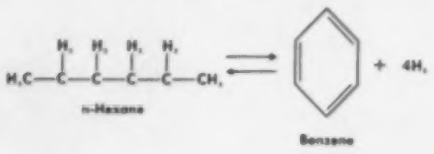
1—Naphthene Dehydrogenation



2—Naphthene Dehydroisomerization

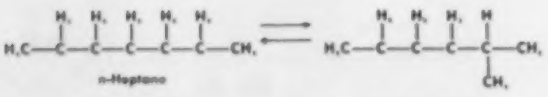


3—Paraffin Dehydrocyclization

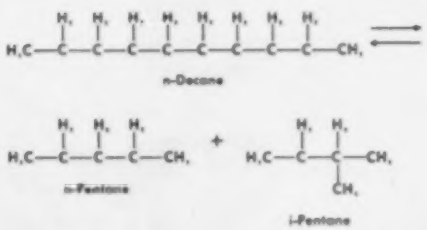


OTHER SUPPORTING REACTIONS

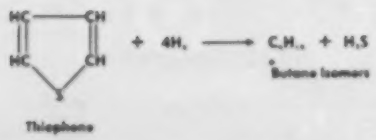
4—Paraffin Isomerization



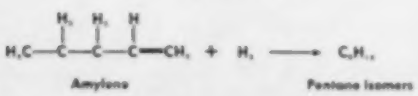
5—Paraffin Hydrocracking



6—Desulfurization



7—Olefin Saturation



...and the Processes You Can Use

By ROBERT L. DAVIDSON, Assistant Editor

THE processes available to the refiner contemplating going to catalytic reforming are numerous, but basically they are all somewhat similar.

They are all designed for continuous operation, they require a relatively narrow boiling range feed stock (200 to 425°F.), they employ a catalyst to promote the chemical rearrangement of the hydrocarbon molecules, and they are carried out in an atmosphere of hydrogen.

They all have a common goal – the upgrading of product quality, by improving octane number and lead susceptibility, by increasing volatility, and by reducing sulfur content.

Because of this similarity, any discussion of the individual processes usually involves a lot of duplication of general information. This article is designed to give you that general information on catalytic reforming in one spot. Then, immediately following and beginning on p. 1176, are more detailed descriptions of each specific process – which give you information peculiar to that specific process.

REFORMING REACTIONS

Most important among the reforming goals is that of octane improvement, which depends primarily on the production of aromatics from naphthenes and paraffins, with other reactions contributing.

However, the process is complicated by the fact that feed stocks contain a mixture of different hydrocarbon types – paraffins, naphthenes, aromatics, and (in the case of cracked stocks) olefins. And each type requires a different chemical reaction for optimum upgrading.

The primary octane improving reactions are (1) dehydrogenation of six-membered ring naphthenes, (2) dehydroisomerization of five-membered ring naphthenes, and (3) dehydrocyclization of paraffins.

Other supporting reactions–of varying significance and magnitude for different processes–include (4) paraffin isomerization, (5) paraffin hydrocracking, (6) desulfurization, and (7) olefin saturation.

Side reactions not contributing to octane improvement include (8) formation of highly aromatic polymers in some processes, and (9) the deposition of carbon on the catalyst.

1 – Naphthene Dehydrogenation

The dehydrogenation of six-membered ring naphthenes – cyclohexane derivatives – to aromatics is the primary octane number improving reaction in catalytic reforming. The reaction is both endothermic and rapid, and contributes materially to both the octane gain and the heat of combustion of the gasoline.

Net octane gain, however, is not as great as in the case of dehydrocyclization of paraffins since the clear octane number of most naphthenes is in the range of 65-80.

Examples of naphthene dehydrogenation include benzene from cyclohexane, toluene from methylcyclohexane and xylenes from dimethylcyclohexane.

Aromatization of naphthenes results in a volumetric shrinkage. When pure methylcyclohexane is converted 100% to toluene, the theoretical volumetric yield is 83.3% with an octane increase of 50 units.

However, the dehydrogenation of naphthenes to aromatics does not always increase octane. The conversion of methylcyclopentane and cyclohexane (F-1 octane blending values of 107 and 110 respectively) to benzene (F-1 of 99) decreases octane, while the conversion of dimethylcyclohexane to xylene increases the blending octane from 68 to 145. For this reason it is often desirable to fractionate gasoline feed stocks to include only the high octane producing naphthenes.

2 – Naphthene Dehydroisomerization

If naphthene dehydrogenation were restricted to six-membered ring naphthenes only, the net effect would be quite small for some stocks. Therefore, it is necessary to isomerize five-membered ring naphthenes–alkyl cyclopentanes–into six-membered ring naphthenes followed by dehydrogenation to aromatics.

While six-membered ring naphthenes convert into aromatics easily with high yields, five-membered ring naphthenes are more difficult to convert, and give lower aromatics yields due to side reactions producing paraffins.

3 – Paraffin Dehydrocyclization

Except for high naphthene content stocks, naphthene aromatization as the sole reforming reaction does not provide adequate octane improvement. The low octane paraffins–unless converted at the same time–will drastically depress the overall reformate octane number.

Aromatization of paraffins is achieved by the dehydrocyclization (dehydrogenation and cyclization) of straight-chain paraffins having at least six carbon molecules. This reaction – which has been known less than twenty years – converts some naphtha components with octanes as low as 10 into aromatic compounds with octanes up to 130.

Paraffin dehydrocyclization produces a substantial density increase with theoretical volumetric yields ranging from 68% for the conversion of n-hexane to benzene to 75-76% for the conversion of n-octane to a mixture of xylenes and ethylbenzene.

Dehydrocyclization is limited in once-through reforming operations. As aromatic concentrations increase through the reactor system, the rate of further dehydrocyclization is greatly reduced. This fact forms one of the bases for the combined "catalytic reforming-aromatics separation-paraffin recycle" processes such as Universal Oil Products Co.'s Rexforming process and Houdry Process Corp.'s Iso-Plus process (details are on pages 1196 and 1197).

4 – Paraffin Isomerization

Paraffin isomerization for increased octane is of little value as the sole catalytic reforming process, but is impor-

tant as a supporting reaction along with naphthene and paraffin aromatization.

A large part of naphtha feed stock is paraffinic, but only a small portion can be converted to aromatics—leaving an appreciable amount of naphtha within the 10-20 octane range. Upgrading 10-20 octane material by isomerization—even if only to 50-60 octane—allows far more of this material to remain in the final product and still meet 90-100 octane specifications.

During paraffin isomerization, methyl and some ethyl groups are shifted from straight-chain to side-chain positions. The carbon-to-carbon bonds—instead of being broken as in cracking—are merely strained, in which condition they shift to side-chain positions producing isomers with increased octanes.

Isomerization of both C_5 and C_6 paraffins is of little value in motor fuel production—though the C_6's are important in benzene production—since in most cases their octanes and lead susceptibilities are high enough so that they do not need catalytic reforming. This gives another reason for excludling light fractions from catalytic reformer feed stock when producing gasoline.

5—Paraffin Hydrocracking

Hydrocracking as a supporting reaction can be useful when reforming feed stocks containing high-boiling fractions. It breaks long-chain paraffins into shorter chains to reduce the overall reformate boiling point, increase product volatility and offset some of the density-yield losses resulting from the aromatization of naphthenes and paraffins.

Hydrocracking of paraffins is defined as the interaction of a hydrocarbon with hydrogen which results in a cleavage of a carbon-to-carbon bond. One hydrogen molecule then adds across the bond which is broken. The reaction is exothermic.

It is important to control the position of cleavage to prevent the breaking off of excessive amounts of methyl groups — demethylation — which results in decreased reforming yields and increased carbon laydown on the catalyst. The point of cleavage can be controlled to some extent by proper catalyst selection and by maintaining the proper hydrogen partial pressure in the reactor.

It is not desirable to hydrocrack C_6-C_8 paraffins since one or both of the products will be butanes or lighter. However, hydrocracking feed stock components boiling above 400°F. not only reduces the amount of high-boiling hydrocarbons, but aids in producing a full boiling range gasoline with a relatively uniform octane number throughout the boiling range.

Volumetric yields from hydrocracking are high. The 100% hydrocracking of decane into two pentane molecules gives a volumetric yield of 118% and an octane gain or more than 100 units.

6—Desulfurization

Virtually all of the combined sulfur compounds in catalytic reformer feed stock are converted to hydrogen sulfide, which is then easily removed from the hydrogen recycle stream or reformate, an advantage not possessed by thermal reforming. This sulfur removal from the reformate increases lead response.

However, hydrogen sulfide acts as a temporary depressant on many reforming catalysts, and the individual refiner must determine the economics of reduced catalyst activity versus the costs of removing hydrogen sulfide from the hydrogen recycle stream, or sulfur removal prior to the reactors.

7—Olefin Saturation

In many cases it is desirable to saturate, desulfurize and increase the octane number of cracked stocks, even though saturation alone of the olefin content of cracked stocks will reduce the octane. Thus, it becomes necessary to induce other reactions such as occur in catalytic reforming.

For olefin saturation, an adequate supply of process hydrogen must be available both to saturate the olefins and to maintain the proper hydrogen partial pressure within the reactor. Though possible to use hydrogen from an outside source, accepted procedure is to mix cracked and virgin stocks so that the dehydrogenation of the virgin stocks will furnish excess hydrogen to saturate the olefins and maintain sufficient process hydrogen.

Elimination of gum forming di-olefins, usually associated with cracked stocks, improves the storage stability of the gasoline—often without gum inhibitors.

8—Aromatic Polymer

Some catalytic reforming processes tend to induce the formation of a small amount of highly aromatic polymer also rich in naphthalenes and especially alkyl naphthalenes. This polymer must be removed from the reformate prior to gasoline blending.

Potential markets for the polymer are the use in wood preservatives and in linseed and tung oil varnishes. In the latter, the resin formed by the condensation with formaldehyde has given excellent results.

9—Carbon Laydown

Carbon laydown on the reforming catalyst can occur in any catalytic reforming process and appreciably reduces the catalyst activity.

Except for fixed-bed Hydroforming, which has two sets of reactors to allow for alternate operation and burning off of carbon every 8 to 16 hours, modern fixed-bed catalytic processes can be considered continuous with little or no carbon laydown under normal operating conditions.

Carbon laydown is minimized by means of maintaining an adequate hydrogen partial pressure and controlling the reformer operating conditions. However, in the event of excessive hydrocracking or demethylation, process upsets, or unduly severe operation, carbon can settle onto the catalyst and shorten its effective "active" life.

Fluid- and moving-bed processes do not try to completely eliminate carbon laydown—as is necessary in continuous fixed-bed processes—but rely on the continuous regeneration of a portion of the circulating catalyst bed.

THERMAL VERSUS CATALYTIC REFORMING

While catalytic reforming depends mainly upon the formation of aromatics and isomers for octane upgrading, thermal reforming obtains the major part of its octane increase by cracking long-chain paraffins to form shorter paraffins, olefins and cyclo-olefins having increased octanes.

Paraffins are more susceptible to thermal cracking than the other straight-run gasoline constituents, therefore naphthenes and aromatics tend to pass through unchanged.

Unfortunately, the steep initial slope of the thermal reforming yield-octane curve cannot be maintained. A limiting value is reached at a yield of about 80-85%. No matter what volumetric loss is taken above this value, there will be very little increase in product octane.

Thermal reforming of high sulfur stocks does not produce a low sulfur product as does catalytic reforming, and

the storage properties of thermal reformate are poor due to gum-forming di-olefins.

An added drawback for thermal reforming is that there is only one volatility-octane relationship, where catalytic reforming can have almost any combination of volatility and octane by changing the major operating conditions.

REACTOR SYSTEMS

In general catalytic reformer reactor systems are based on three main methods of handling the catalyst. These are:

1–Fixed-bed reactors, where the catalyst remains in a fixed position during its entire onstream life.

2–Moving-bed reactors, where granular or pelletized catalyst is continuously circulated through the reactor so as to contact the reacting feed stock.

3–Fluid-bed reactors, where the continuously circulating catalyst is in such a finely divided state as to behave similarly to a fluid.

A major consideration in all catalytic reforming processes is to approach isothermal reaction temperatures. Since the overall reforming process is endothermic, heat must be added to the process in order to maintain the reactants at the optimum temperature. A portion of this make-up heat is supplied by preheating naphtha feed stock and recycle hydrogen prior to the reactors, but these alone are not sufficient to prevent the temperature of the reactants from dropping as the reaction proceeds.

Fixed-bed catalytic reforming processes approach an isothermal reaction system by dividing the total reaction system into several separate reactors with reheating facilities between the reactors.

Moving- and fluid-bed systems use single upright reactor towers and maintain isothermal conditions by heat from the mass of hot regenerated catalyst itself, or heating spaced along the reaction tower.

Mechanics for fluidized solids in reactors have been described in previous articles, as given in the bibliography on pp. 1203-04 (references 8, 9), as have those for moving-bed reactors (references 67, 68).

REFORMING CATALYSTS

A number of catalyst types are used for petroleum naphtha reforming. Broadly speaking, they include the platinum-containing catalysts used for modern fixed-bed catalytic reforming (Catalytic Reforming with Sinclair-Baker RD-150 catalyst, Catforming, Houdriforming, Iso-Plus, Platforming, Rexforming, Sovaforming and Ultraforming), cobalt-molybdena and chromia-alumina catalysts used for moving-bed catalyst reforming (Hyperforming and Thermofor Catalytic Reforming, respectively), and molybdena-alumina catalysts used for fixed-bed Hydroforming and fluidized-solids reforming (fluid Hydroforming and Orthoforming).

Platinum-containing catalysts for fixed-bed reactors are usually pelletized, tableted or extruded to give a diameter of about ⅛-in. Supports for the very small percentages of reduced-state platinum used (less than 1%) include alumina and silica-alumina.

Moving-bed processes use small catalyst beads or pellets, while fluidized-solids processes use catalyst in the micron range.

Naphtha reforming reactions require "acid type" catalysts to catalyze carbonium ion reactions. This acid may be provided by one of the oxides in the catalyst base, may be in the form of some halogen compound added to the catalyst, or may be by direct addition of acid type materials to the reformer feed stock itself.

Catalyst activity or life can be reduced by contamination with copper, TEL, sodium hydroxide and other common catalyst poisons. The extent of this poisoning will vary between catalysts used by different process licensors.

If the acid constituent of the catalyst is water soluble, water must be excluded from the feed stock.

Carbon laydown on the catalyst also reduces the activity of the catalyst, requiring that the catalyst be regenerated, if possible, or reprocessed.

Hydrogen sulfide selectively suppresses catalyst activity linearly with regard to certain reactions. Above a certain threshold value for hydrogen sulfide, catalyst activity is improved by removing the hydrogen sulfide from the recycle gas, or removing sulfur preceding the reactors.

OPERATING CONDITIONS

The major process variables in catalytic reforming include temperature, pressure, space velocity and hydrogen recycle rate. For fluid- and moving-bed processes, the catalyst circulation rate is an additional process variable.

Optimum production of light aromatics does not occur under the same conditions as for motor fuels. In general, aromatics production is at higher temperatures and lower pressures than for optimum motor gasoline production.

Reactor temperatures range from 800 to 1000°F. for catalytic reforming. If the temperature is too low there will be little aromatization of naphthenes and paraffins, and if too high, there will be excessive hydrocracking of heavy paraffins.

A gradual increase in reactor temperature compensates for catalyst deactivation caused by carbon laydown in fixed-bed catalytic reformers.

Reactor pressures range from 100 to 1000 psig for the various reforming processes.

The presence of a high hydrogen partial pressure in the reactor system reduces hydrocracking, carbon laydown on the catalyst and demethylation during hydrocracking. Therefore as the feed stock end boiling point is increased, it is advisable to increase reactor pressure to reduce hydrocracking of high-boiling compounds and catalyst coking.

For light aromatics production low pressures are desirable. Above 300 psig the equilibrium amount of benzene from cyclohexane and cyclopentanes decreases rapidly. The equilibrium toluene concentration remains high to a much higher pressure than benzene.

The highest reactor pressure is limited by a combination of economic considerations and the corresponding maximum allowable temperature needed for a given quality of reformate without producing an excessive amount of thermal reactions. Low pressure limits are controlled by the desired amount of hydrocracking and by maximum allowable carbon laydown on the catalyst.

Reactor space velocity can vary from less than 1 v/hr./v up to 5. Lower space velocities increase hydrocracking, but have little effect on aromatization. Increased space velocities (at constant severity) require higher temperatures, but do not affect catalyst life in barrels per pound of catalyst.

GASOLINE OPERATION

In general, any straight-run naphtha can be feed stock for catalytic reforming to high octane motor fuels. The primary limitations are the olefin and sulfur contents and the initial and end boiling points of the feed stock.

If the olefin content of the feed stock is too high, the hydrogen balance of the reforming reaction will be upset. Excessive sulfur in the feed stock will hydrogenate to hydrogen sulfide and depress the reforming catalyst activ-

ity, and might require the removal of hydrogen sulfide from the recycle stream or of sulfur prior to the reactors.

Boiling point limitations are set by a combination of the final product desired, catalyst life and optimum use of the reformer. The reformate end boiling point will be 15-25°F. higher than that of its feed stock, due to the aromatization of naphthenes and paraffins and the resultant density increases.

A feed stock end boiling point of 400°F. is the usual maximum value in order for the reformate to meet gasoline boiling point specifications, though feed stocks with end boiling points up to 425°F. and higher can be used if the reformer is operated so as to hydrocrack high boiling paraffinic components. However, hydrocracking can cause increased carbon laydown on the catalyst and increased yield losses to butanes and lighter, if carried to an extreme.

Optimum reformer utilization is obtained by not using feed stock constituents boiling much below 200°F.–which do not contribute greatly to increased octane during reforming–as these merely take up reformer capacity better used for high-boiling materials more susceptible to octane upgrading. However, the small refiner might find it more economical to run a wide cut stock to the catalytic reformer rather than invest in facilities to handle light ends.

When feeding cracked stocks to a catalytic reformer, it is usually best to reform only the portion boiling above 200°F. which has low octane, high sulfur, and poor storage properties. The portion boiling below 200°F. has fairly good octane without reforming.

Catalytic reformate is essentially free of combined sulfur and gum forming di-olefins, therefore catalytic reformates have good lead susceptibilities and storage properties. As previously pointed out, aromatic polymer–formed during reforming with some of the commercial processes–must be removed prior to blending the reformate in gasoline stocks. This polymer removal can be effected by rerun distillation of the reformate, or by polymer knock-out towers.

Thermal reforming of the catalytic reformate, or a recycle of a raffinate from which aromatics have been removed, produces sizable product octane increases.

AROMATIC OPERATION

Both feed stocks and operating conditions for aromatics production differ from those needed for optimum motor fuel production.

To reform for aromatics it is usually better to run close-boiling cuts to get a high naphthene conversion at minimum yield loss. High-boiling naphthenes have faster rates and more favorable reaction equilibria than lower boiling naphthenes. Therefore if a C_6-C_8 cut is charged, the high reforming severity needed for the C_6's would overtreat the C_7's.

Paraffin dehydrocyclization is sensitive to aromatics concentrations, and requires a very paraffinic feed to give reasonable amounts of aromatics.

In general optimum yields of aromatics are obtained when operating at higher temperatures and lower pressures than for motor fuel octane upgrading.

CATALYTIC REFORMING PROCESSES

The major catalytic reforming processes which are commercially available are presented in detail on pages 1176 to 1196.

Other catalytic reforming processes which deserve mention are described briefly in the following.

1–Fixed-Bed Hydroforming

This was the first commercial catalytic reforming process, with the first unit onstream Nov., 1940 at the Pan American Refining Co. (now American Oil Co.), Texas City, Texas, refinery. However, no new units have been built since the war.

Fixed-bed hydroforming is cyclical in that two of the four catalyst cases are on regeneration while the other two are on the process cycle.

Reforming temperatures are 900-1000°F., pressures are 150-300 psig and liquid hourly space velocities about 0.5. A hydrogen partial pressure of 40-90% is maintained in the reactors using recycle gas containing about 70% hydrogen.

The catalyst consists of about 9% molybdenum oxide deposited on activated alumina granules or pellets about 2-4 mesh in size. Regeneration burns deposited carbon off of the catalyst–using air diluted with flue gas at 1050-1100°F.–and reoxidizes the partially reduced molybdenum oxide. In addition, sulfides which have reacted with the molybdenum oxide are removed during regeneration. Regeneration is required after about 4-16 hours onstream time.

Reaction products from the reformer are recovered and fractionated in a four-tower system to give (1) hydrogen-rich gas (2) depropanized 400°F. end point gasoline, and (3) an aromatic polymer boiling above 400°F.

During the war fixed-bed Hydroformers were used primarily for the production of toluene and higher aromatics for aviation gasoline blending. After the war most of these units were either converted to motor gasoline production or shut down. A list of the domestic fixed-bed Hydroformers is as follows:

Continental Oil Co., Ponca City, Okla.
Humble Oil and Refining Co., (Baytown Ordnance Works), Baytown, Texas*
Pan American Refining Corp., Texas City, Texas
The Pure Oil Co., Toledo, Ohio
Standard Oil Co. (Indiana), Whiting, Ind.
The Texas Co., Lockport, Ill.
Union Oil Co. of Calif., Oleum, Calif.

The molybdena-alumina catalyst used in fixed-bed Hydroforming has now been modified and "fluidized" for use in fluid Hydroforming and Orthoforming.

2–Sovaforming

This is the Socony Mobil Oil Co., Inc., three-reactor, fixed-bed catalytic reforming process using the Sinclair-Baker RD-150 catalyst (for additional catalyst details, see pages 1202-03).

Sovaforming is not available for licensing and further details on the process have not been released to date. However, Socony Mobil has announced plans for the installation of seven Sovaformers–two of which are already onstream–at refineries within their company and subsidiaries.

3–Cycloversion

Another catalytic process is Cycloversion–developed by the Perco Div. of Phillips Petroleum Co.–with the first commercial unit onstream in 1940. However, this process –capable of catalytic desulfurization, cracking and reforming–is mild compared to the other catalytic reforming processes and operates without the benefit of hydrogen recycle to the reactors. There is some question as to whether it should be included in a tabulation of modern catalytic

*Recently converted to an Ultraformer.

reforming. At present, the majority of the Cycloversion units are used for desulfurizing straight-run and cracked gasolines, naphtha fractions and kerosines.

Cycloversion process is cyclic–as is fixed-bed Hydroforming–using two reactors for continuous operation. One reactor will be undergoing regeneration while the other is on the process stream. A reforming cycle will last from 12 to 72 hours before the reactor catalyst requires regeneration due to carbon laydown. The catalyst used is cyclocel grade bauxite, and is a naturally occuring material.

A typical example for Cycloversion reforming is for a 271-416°F. naphtha cut with a F-1 clear octane of 42.7 giving a reformate with a F-1 clear octane of 68.0 and boiling in the 129-442°F. range.

Catalytic Reforming–from 1940 to Today

TWENTY-FOUR years ago the petroleum industry met its first major octane challenge by the development of thermal reforming. A number of these processes appeared almost simultaneously around 1931 as the "obvious" answer to increased octane needs.

Thermal reforming, however, reigned less than a decade, during which time its limited octane potential and poor volumetric yield led to the use of supplementary processes –polymerization of thermal reformer make-gas olefins to improve the over-all octane-yield relationship–and competing processes having improved yields–polyforming and isoforming.

During this period studies were being made on methods of obtaining aromatics from petroleum, which in 1939 led to the first truly catalytic reforming process–fixed-bed Hydroforming–developed by the Standard Oil Development Co. (now Esso Research and Engineering Co.).

Where thermal reforming had produced few aromatics, and had relied on the cracking of high boiling paraffins and the formation of unsaturates for octane improvement, fixed-bed Hydroforming used a molybdena-alumina catalyst to convert naphthenes and some paraffins into high octane aromatic compounds.

The first fixed-bed Hydroformer went on stream at the Pan American Refining Corp. (now American Oil Co.) refinery at Texas City, Texas, in November of 1940 with the primary purpose of producing high octane motor gasoline blending components.

Two more fixed-bed Hydroformers were built prior to World War II, and five were built during the war years.

The fixed-bed Hydroformer was a much needed solution for wartime toluene for trinitrotoluene and for high octane aviation blending components. By April of 1942, a single petroleum refinery was producing more toluene than the entire coal tar industry.

Following the war, most of the fixed-bed Hydroformers were either converted to motor gasoline production, or were shut down. One outstanding exception to this was the Baytown Ordnance Works–purchased by Humble Oil and Refining Co.–which continued to produce toluene and xylenes as well as processing virgin naphthas for octane improvement. Recently, this unit was converted into an Ultraformer.

No new catalytic reforming units were installed during the four year period following World War II.

Then in March of 1949 Universal Oil Products Co. introduced its Platforming process–which was continuous in operation, in contrast to the cyclic operation of the fixed-bed Hydroformers.

Platforming – so named as it was the first commercial reforming process using a platinum-containing catalyst– was first commercially onstream October 28, 1949 at the Old Dutch Refining Co. (now Aurora Gasoline Co.) at Muskegon, Mich.

The race had started. Within the next two years four more processes were announced.

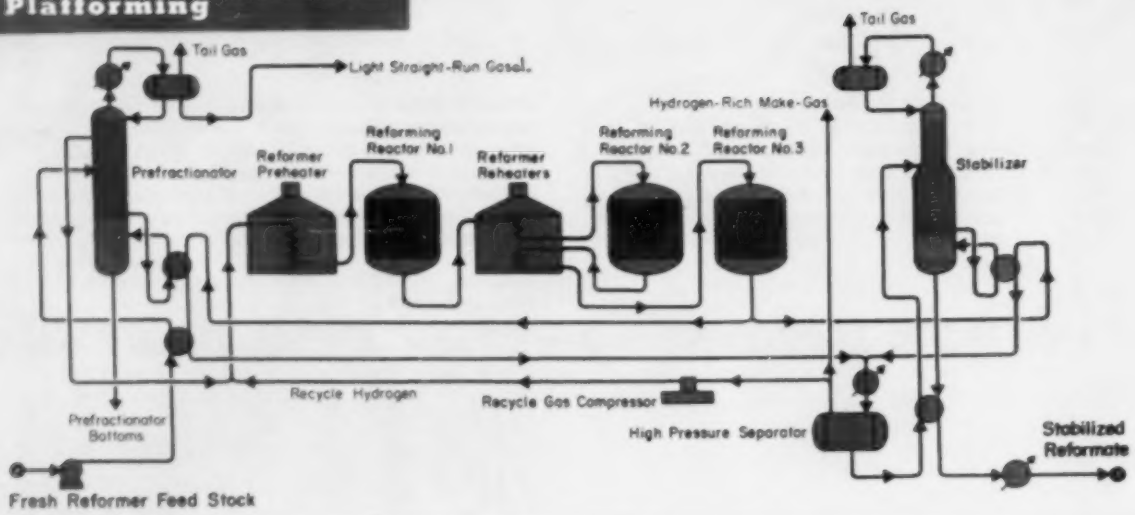
During the following four years seven more catalytic reforming processes or variations were publicly announced.

The "Boxscore" on this page tabulates all of the major catalytic reforming processes with information concerning their source of development and their first onstream commercial installations.

Boxscore for Catalytic Reforming Processes

Process name	Developed by	Date Process Announced	First unit placed onstream at: Company	Location	Date
Fixed-Bed Hydroforming	Standard Oil Development Co.[1]	1939	Pan American Refg. Co.[2]	Texas City, Texas	Nov., 1940
Platforming	Universal Oil Products Co.	Mar., 1949	Old Dutch Refining Co.[3]	Muskegon, Mich.	Oct., 1949
Catforming	Atlantic Refining Co.	Feb., 1951	McBride Oil & Gas Corp.	La Blanca, Texas	Aug., 1952
Houdriforming	Houdry Process Corp.	May, 1951	Sun Oil Co.	Marcus Hook, Pa.	Nov., 1953
Thermofor Catalytic Reforming	Socony-Vacuum Oil Co., Inc.[4]	May, 1951	General Petroleum Corp.	Torrance, Calif.	Mar., 1955
Fluid Hydroforming	Standard Oil Development Co.[1]	May, 1951	Pan-Am. Southern Corp.	Destrehan, La.	Dec., 1952
Hyperforming	Union Oil Co., of Calif.	Feb., 1952	Calstate Refining Co.	Signal Hill, Calif.	May, 1955
Sinclair-Baker RD-150 catalyst	Baker & Co. with Sinclair Refining Co.	May, 1953	The Pure Oil Co.	Heath, Ohio	Sept., 1954
Orthoforming	M. W. Kellogg Co.	July, 1953	Standard Oil Co. (Ind.)	Whiting, Ind.	April, 1955
Ultraforming	Standard Oil Co., (Indiana)	Nov., 1953	Pan-Am. Southern Corp.	El Dorado, Ark.	May, 1954
Sovaforming	Socony-Vacuum Oil Co., Inc.[4]	Jan., 1954	General Petroleum Corp.	Ferndale, Wash.	Nov., 1954
Rexforming	Universal Oil Products Co.	Mar., 1955	none onstream yet[5]		
Iso-plus	Houdry Process Corp.	Mar., 1955	none onstream yet		

[1]Now Esso Research and Engineering Co. – process developed in conjunction with Standard Oil Co. (Ind.) and the M. W. Kellogg Co.
[2]Now American Oil Co.
[3]Now Aurora Gasoline Co.
[4]Now Socony Mobil Oil Co., Inc.
[5]Cities Service Oil Co. plans a 6,000 b/sd unit at Ponca City, Okla.



Platforming

Process Type—Catalytic reforming of petroleum naphthas with platinum-containing catalyst through a series of fixed-catalyst-bed reactors.

Catalyst—Comprised of alumina with platinum and halogen in ⅛-in. pellets (the use of platinum catalysts in reforming was pioneered by UOP). Catalyst lives of over 100 barrels feed per pound of catalyst while producing 95 F-1 leaded octanes have been obtained in many commercial installations, and lives of over 250 bbl./lb. have been reported. Commonly occuring catalyst poisons, when present in appreciable amounts, include nitrogen, arsenic and some metals.

Regeneration—Regeneration is possible, but economically unjustifiable.

Feed Stocks for Gasoline—Can be straight-run natural and thermally cracked gasolines with end boiling points up to 400°F. and no lower limit for initial boiling point.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production.

Feed Stock Preparation—Sulfur is a temporary catalyst depressant and can be removed prior to the Platformer, or hydrogen sulfide can be removed from the recycle hydrogen stream by an amine scrubber. Hydrocarbons boiling above 400°F.–likely to give excessive hydrocracking and carbon laydown, or form polymers–should be removed prior to the reactors.

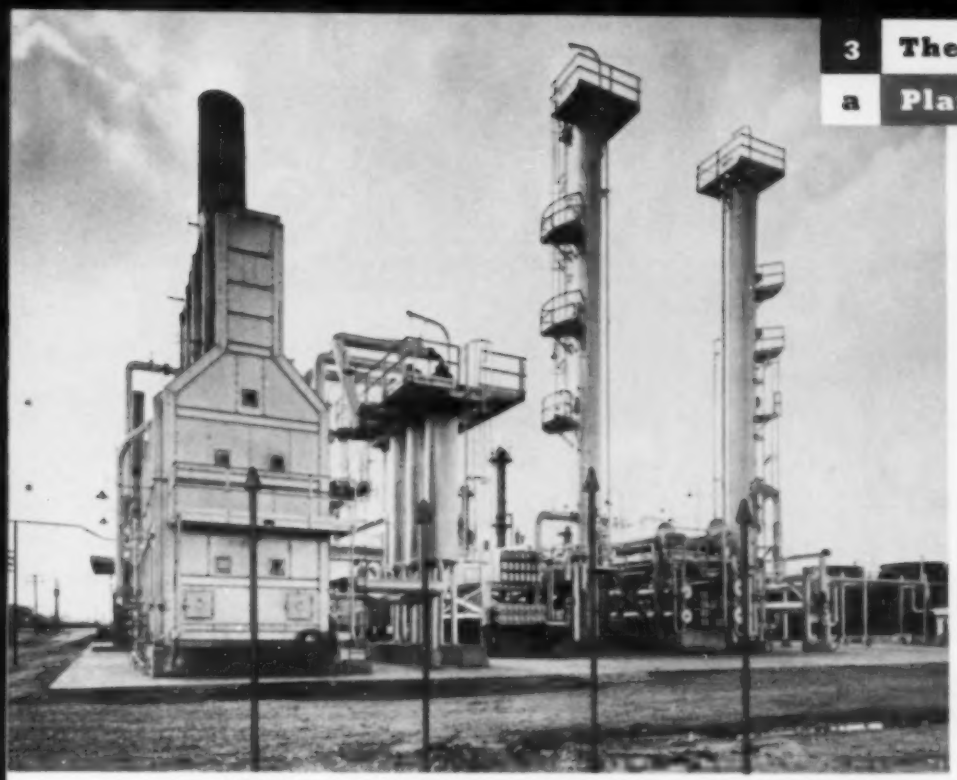
Process Operation—Referring to the flow diagram–feed stock, following preparation, is combined with the recycle hydrogen stream and the mixture is heated, then passed through the three reactors and two interheaters. Third reactor effluent is cooled, then separated into hydrogen-rich gas and reformate. Reformate is charged to a stabilizer.

Operating Conditions—Typical ranges of operating conditions are temperatures from 850-1,000°F. and pressures from 200 to 1,000 psig. At higher pressures, debutanized reformate RVP's, % distilled at 212°F., and C_5 yield are greater and the aromatics content-octane number relationship better for a given octane number than for low pres-

Table 1—Platforming of Different Naphtha

Feed Stock Source	Venezuela		Mid-Continent		Middle East	
Gravity, °API	48.6		52.5		54.5	
ASTM distillation, °F						
IBP	272		237		272	
10%	284		261		282	
30	292		288		290	
50	302		318		300	
70	316		352		316	
90	338		376		342	
EP	378		404		378	
F-1 clear octane	52.2		31.5		32.4	
F-1 + 3cc TEL	73.6		60.7		55.2	
Sulfur wt.%	0.022		0.03		0.064	
Naphthenes, vol.%	40		44		20	
Aromatics, vol.%	21		10		14	
Paraffins, vol.%	39		46		66	
Reformate						
Reforming Severity	Low	High	Low	High	Low	High
Yields, charge basis:						
Debut. Reformate, vol.%	91.5	85.2	87.0	79.2	84.0	79.0
Total Butanes, vol.%	3.0	6.4	5.3	9.6	8.4	11.1
Debutanized Reformate						
ASTM Distillation, °F						
IBP	175	130	160	130	130	120
10%	260	225	210	185	185	165
30	285	280	255	240	245	225
50	300	300	290	280	280	275
70	320	320	325	315	305	305
90	345	345	375	365	340	340
EP	410	415	425	435	410	415
F-1 clear octane	85.0	95.0	85.0	95.0	85.0	92.0
F-1 + 3cc TEL	94.5	99.5	95.5	+0.05*	96.0	99.5
Gravity, °API @ 60°F.	44.0	42.5	46.5	44.5	51.0	49.0
RVP, psi	1.4	2.3	2.1	3.3	3.2	4.0
10 lb. RVP Reformate						
F-1 clear octane	86.0	95.0	86.0	95.0	86.0	92.2
F-1 + 3cc TEL	95.5	99.8	96.0	+0.05*	96.5	99.7
Vol. % of charge	104.7	96.4	98.6	87.4	93.1	86.9
Gravity, °API	51.0	49.0	52.5	49.5	56.0	53.5
Outside n-C_5 Required, LV% Chg.	11.6	6.5	7.8	0.5	2.1	−1.6

*iso-octane + cc TEL/gal.



PLATFORMER at Rock Island Refining Corp., Indianapolis, Ind.—2400 b/sd

sures. At F-1 + 2 cc. TEL octanes up to 95, pressure has little effect on yield, but for higher octanes, lower pressures give better yields.

Product—Gasoline Operation—Stabilized reformate is a finished product ready for direct blending into gasoline pools. Table 1 presents examples of reformate from different naphtha sources, and Table 2 illustrates the isomerization of hexane during Platforming.

Product—Aromatics Operation—Table 3 presents data on Platforming for toluene at the Old Dutch Refinery, Waukegan, Mich.

Equipment—No information furnished concerning the use of special equipment or alloys.

Economics—Platformer construction costs are from $125/bbl. of feed stock for larger units to $300/bbl. for very small units. Operating costs are 20-35¢/bbl. of feed stock, including labor, supervision, utilities, laboratory, maintenance, taxes and insurance, royalty and catalyst.

Installations—There are approximately 73 Platformers operating in the U.S. and Canada with capacities from 600 to 29,000 b/sd, and a total capacity of 479,640 b/sd. In addition, approximately 28 additional units are licensed or under construction with capacities from 600 to 26,000 b/sd and a total capacity of 154,120 b/sd. For a detailed tabulation of installations, see pp. 1166-69.

Table 2 — Hexane Isomerization

Compound	Charge, vol. %	Product, vol. %
2,2-dimethylbutane	0.7	4.9
2,3-dimethylbutane	2.6	6.0
2-methylpentane	19.5	30.2
3-methylpentane	19.4	23.1
n-hexane	57.8	35.8
	100.0	100.0

and a total capacity of 123,894 b/sd. For a detailed tabulation of installations, see pp. 1166-69.

Licensor—Universal Oil Products Co., 30 Algonquin Road, Des Plaines, Illinois.

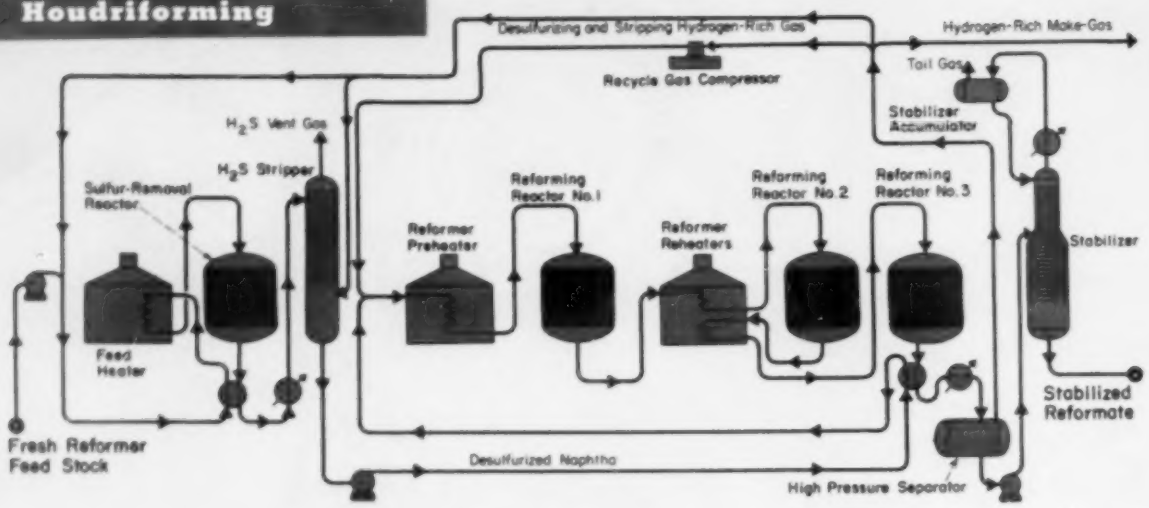
Table 3 — Toluene Production by Platforming

(feed stock narrow boiling "pre-toluene" fraction from Gulf Coast crude)

Feed Stock	Wt. %
C_7 and C_8 paraffins	28
C_7 and C_8 naphthenes	62
Toluene	10
Gravity, °API	57.4
ASTM distillation, °F	
IBP	202
10%	205
50%	208
90%	212
EP	224

Product	Run I	Run II
Gas	14.0	14.4
Hydrogen	2.4	2.4
Methane	0.4	0.5
Ethane	1.7	1.7
Propane	4.2	4.1
C_4's+	5.3	5.7
Light Platformate	27.0	22.2
C_4's	1.0	1.0
C_5's	3.3	4.1
C_6 and C_7 P + N*	14.3	12.8
Benzene	0.9	0.9
Toluene	7.5	3.4
Heavy Platformate	59.0	63.4
Toluene	48.3	49.9
Ethylbenzene	1.2	1.3
Metaxylene	3.6	3.9
Paraxylene	1.8	1.3
Orthoxylene	1.2	1.3
C_7 and C_8 P + N*	2.9	5.7
Gross molal aromatics yield, % of theoretical	95	91

*P + N = Paraffins plus naphthenes



Houdriforming

Process Type—Catalytic reforming of petroleum naphthas with platinum-containing, regenerable catalyst through a series of fixed-catalyst-bed reactors.

Catalyst—Pelleted platinum-containing catalyst–Houdry Type 3–manufactured by Houdry Process Corp., at Paulsboro, N. J. Concerning catalyst life, Sun Oil Co.'s 15,000 b/d Houdriformer at Marcus Hook, Pa., has been onstream since Nov. 1953 without regeneration or catalyst change. Catalyst poisons include metals such as lead, nickel, copper, arsenic, etc. Also protection against excess water, sulfur, nitrogen, oxygen and oxygenated compounds should be provided.

Regeneration—Not needed for normal operation at moderate severities, but can be provided in case of high severity operation or process upsets. Regeneration time–depending upon length and severity of run–will restore full catalyst activity and selectivity, and is performed by burning off catalyst deposits.

Feed Stocks For Gasoline—Napthas with initial boiling points of 175-300° F. and end boiling points up to 400° F.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production.

Feed Stock Preparation—A "guard case" catalytic hydrogenation pretreating stage–using the same catalyst as the Houdriformer reactors–is available for on-the-line feed stock purification, giving almost total desulfurization and removal of other platinum catalyst poisons. In addition, the guard case hydrogenates (saturates) olefin-containing stocks. In general, the guard case not needed when reforming naphthas with less than 0.02% sulfur. With higher sulfur contents, the economics of desulfurization will vary for each situation.

Process Operation—Referring to the flow diagram, naphtha feed stock is heated, then joined with high-pressure separator hydrogen. The combined stream then goes to "guard case" desulfurization system, and resulting hydrogen sulfide is removed in stripping tower with another portion of separator hydrogen. Stripper effluent is heated and mixed with recycle hydrogen, the mixture flowing through the three reforming reactors and two interheaters. Third reactor effluent is cooled, then separated into a hydrogen-rich gas stream–part of which is used in desulfurization and hydrogen sulfide stripping, and part for recycle to the reforming reactors–and an unstabilized liquid reformate stream. The liquid stream is stabilized to the desired vapor pressure.

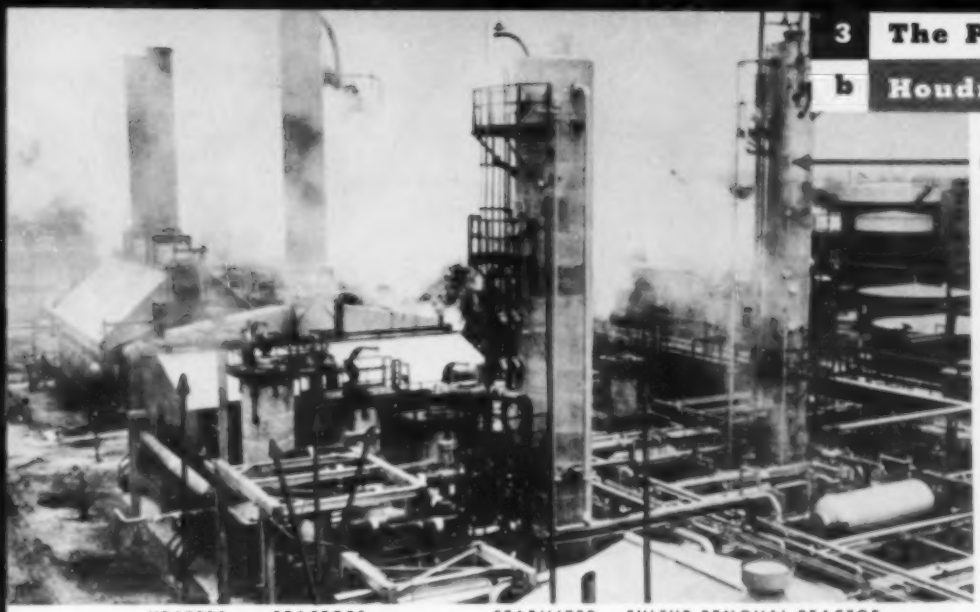
Operating Conditions—Typical ranges of operating conditions are temperatures from 875-950° F., pressures from 250-600 psig, space velocities from 1.5-5.0 v./hr./v, and hydrogen/oil mole recycle ratio 4-10.

Product—Gasoline Operation—Low octane straight-run naphthas have octane increases of from 40 to 70 with high liquid volume recovery. On highly naphthenic stocks, reformates with F-1 clear octanes over 100 have been obtained. By-product hydrogen produced has purities of 85-90%, and is usually 600-1000 cubic feet per barrel of reformer feed. There is no polymer formation and reformate is a finished product ready for blending directly into refinery pool gasoline. Table 1 presents feed stock and reformate data for crude from various sources.

Product—Aromatics Operation—Yields up to 100% of theoretical in conversion of naphthenes to benzene, toluene and xylenes are approached. Paraffin aromatization is significant. By-product hydrogen has greater than 95% purity. Tables 2 and 3 present data for typical aromatics operations.

Equipment—No information furnished concerning the use of special equipment or alloys.

Economics—A detailed refinery economic study of the Houdriformer in conjunction with Houdriflow, thermal reforming and cracking, visbreaking and polymerization of olefins is presented in a paper by Burtis and Noll, "Houdriforming – Its Place in the Refining of Petroleum" (see Bibliography, pp. 1203-04, under "Houdriforming").



HOUDRIFORMER at Crown Central Petroleum Corp., Pasadena, Texas–5000 b/sd

Licensor—The Houdry Process Corp., executive and sales offices in Philadelphia, Pa.–research and development laboratories at Linwood, Pa.

Installations—Seven Houdriformers are in operation in the U. S. and Canada with capacities of 1000 to 18,000 b/sd, and a total capacity of 55,300 b/sd. Three more Houdriformers with capacities of 500 to 25,000 b/sd, and a total capacity of 26,500 are licensed or under construction in the U. S. and Canada. In addition, two foreign units having a total capacity of 7,200 b/sd have been licensed for construction.

Table 1—Houdriforming of Different Naphtha Types

Feed Stock Source	Mixed Crudes		East Texas		Kuwait		Natural Gas' Condensate	
Gravity, °API	45.8		55.3		52.9		58.8	
ASTM distillation, °F								
IBP	255		188		244		230	
10%	285		2.5		289		248	
50%	316		252		320		278	
90%	361		317		366		351	
EP	401		368		398		394	
F-1 clear octane	61.3		55.6		23.5		24.6	
F-1 + 3 cc TEL	79.0		76.3		46.1		55.4	
RVP, psi	0.6		0.7		0.6		—	
Sulfur, wt.%	0.012		0.006		0.10		0.003	
Naphthenes, vol.%	46		42		20		17	
Aromatics, vol.%	23		14		15		6	
Paraffins, vol.%	31		44		64		77	
Olefins, vol.%	0		0		1		0	
Reformate								
Reforming severity	Low	High	Low	High	Low	High	Low	High
Yields, charge basis								
Debutanized reformate, vol.%	88.3	80.6	91.0	83.5	87.4	80.4	80.8	78.1
Butanes, vol.%	3.9	7.0	2.7	6.2	6.1	9.3	9.2	9.9
Propane, wt.%	2.0	5.0	1.2	3.8	2.8	4.7	5.2	6.9
Ethane, wt.%	1.0	2.9	0.8	2.4	1.5	2.8	2.3	3.0
Methane, wt.%	0.6	1.8	0.5	1.0	1.1	2.2	1.1	1.5
Hydrogen, wt.%	2.0	1.8	1.6	1.3	0.7	0.7	1.1	0.9
Debutanized reformate								
F-1 clear octane	92.0	101.0*	80.0	92.0	76.8	90.0	80.1	82.3
F-1 + 3 cc TEL	99.2	104.2*	92.5	99.5	91.0	98.3	93.0	93.3
Gravity, °API	39.7	36.5	52.7	45.8	50.7	47.7	53.2	54.0
ASTM distillation, °F.								
IBP	170	148	173	149	141	130	131	127
10%	248	230	212	196	216	195	183	179
50%	306	306	260	248	284	283	264	251
90%	378	375	323	325	340	349	345	326
EP	460	465	379	392	413	426	432	412
RVP, psi	1.0	1.9	1.0	3.0	2.1	3.6	3.0	2.7
Sulfur, wt.%	0.002	0.002	<0.001	0.002	<0.001	<0.001	nil	nil

*Octanes above 100 extrapolated by method of Deters, J. F., *Petroleum Refiner* June, 1951.
(1)—Paraffinic naphtha (230-394°F.) from natural gas condensate.

Table 2 — Aromatics Reformate from C_6-C_7 Feed

Houdriformer reformate yield

Debutanized liquid, vol.% of charge	89.3
C_4's, vol.% of charge	2.6
Propane, wt.% of charge	1.1
Ethane, wt.% of charge	0.3
Methane, wt.% of charge	0.2
Hydrogen, wt.% of charge	2.7

Component analysis, volume per cent

	Feed stock	Debut. prod.
Benzene	1.4	15.6
Toluene	4.6	31.7
Methylcyclopentane	4.6	2.8
Cyclohexane	13.9	0.8
Dimethylcyclopentanes	9.6	3.0
Methylcyclohexane	23.1	0.3
Olefins	—	0.9
Paraffins	42.8	44.9

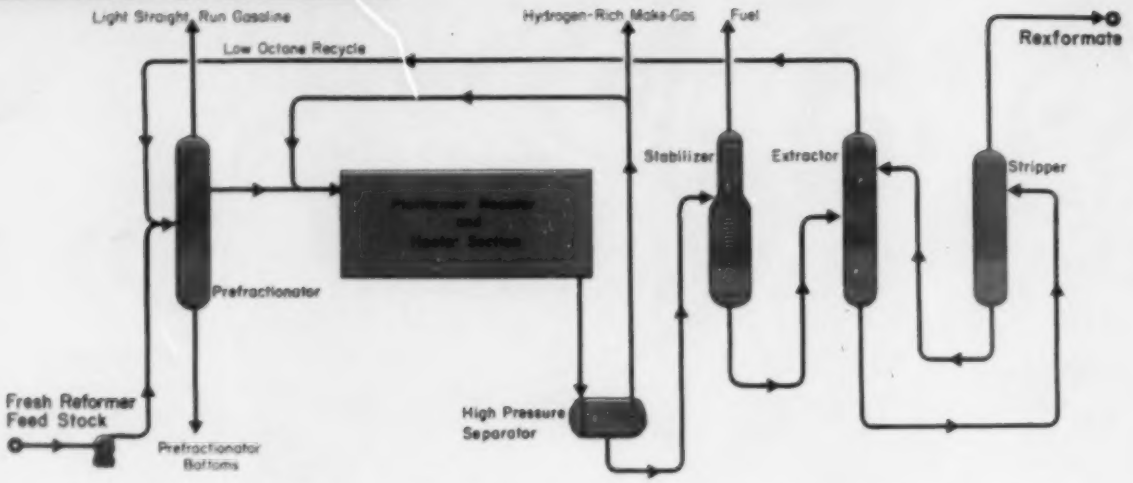
Table 3 — Aromatics Reformate from C_8 Feed

Houdriformer reformate yield

C_5^+ liquid, vol.% of charge	91.1
C_4's, vol.% of charge	1.8
Propane, wt.% of charge	0.9
Ethane, wt.% of charge	0.4
Methane, wt.% of charge	0.2
Hydrogen, wt.% of charge	2.1

Component analysis, volume per cent

	Feed stock	C_5^+ prod.
Toluene	—	5.4
C_8 aromatics	1.9	30.3
C_9 aromatics	1.1	5.1
Naphthenes	42	2.0
Olefins	—	2.0
Paraffins	55	52.2
F-4 + 4.6cc TEL aviation blending P.N. (aromatic portion)	—	190



Rexforming

Process Type—Combination process, to produce F-1 clear octanes exceeding 100, utilizing a conventional Platforming unit in conjunction with an aromatics extraction unit, the low-octane paraffinic extractor raffinate recycling back to the Platformer.

Process Operation—The extent to which paraffin dehydrocyclization proceeds in once-through operations is limited by the presence of aromatics. Thus all once-through catalytic reforming processes have small, but important, amounts of residual low octane paraffins reducing the overall reformate octane. By use of a liquid-liquid extraction process, high octane aromatics and paraffins can be separated from the low octane non-aromatics, in the reformate.

Table 1 — Rexforming of Naphtas

		Reformate[2]			Rex-
	Charge[1]	Test 1	Test 2	Charge	formate[2]
Gravity, °API	52.5	44.3	37.3	59.6	47.1
100 ml distillation, °F					
IBP	248	124	120	254	110
5%	264	162	160	265	153
10%	270	180	189	268	167
30%	289	249	288	282	239
50%	312	297	326	296	278
70%	340	339	353	320	306
90%	370	382	392	351	345
95%	379	402	413	365	364
EP	390	426	429	390	415
F-1 clear octane	30.0	95.2	101.8[3]	10.3	101.0
Aromatics, vol.%	8	56	77	3	59
Naphthenes, vol.%	—	—	—	12	—
Yields, charge basis					
Debut. Rexformate, vol.%	—	82.9	76.8	—	68.2
Separator gas, SCF/bbl.	—	856	1090	—	940
Debutanizer gas, SCF/bbl.	—	246	296	—	484
10 lb. RVP Rexformate, vol.%	—	92.3	85.0	—	74.3

(1) Typical Mid-Continent charge.
(2) Properties and yields are for debutanized Rexformate except for 10 lb. RVP gasoline.
(3) C.R.C. octane scale extension.

The low octane stream may then be handled in a separate catalytic reforming section, but laboratory and pilot plant units have proved it practical to recycle this material to the reactors in admixture with fresh reformer feed.

Operating Conditions—Rexforming severities are lower than for conventional once-through operations. Rexforming temperatures can be as much as 50°F. lower, and, on a fresh feed basis, space velocities are higher than for once-through operations, thus lengthening catalyst life.

Product—Gasoline Operation—Table 1 illustrates Rexforming for typical Mid-Continent and high paraffin naphthas to produce greater than 100 F-1 clear octanes.

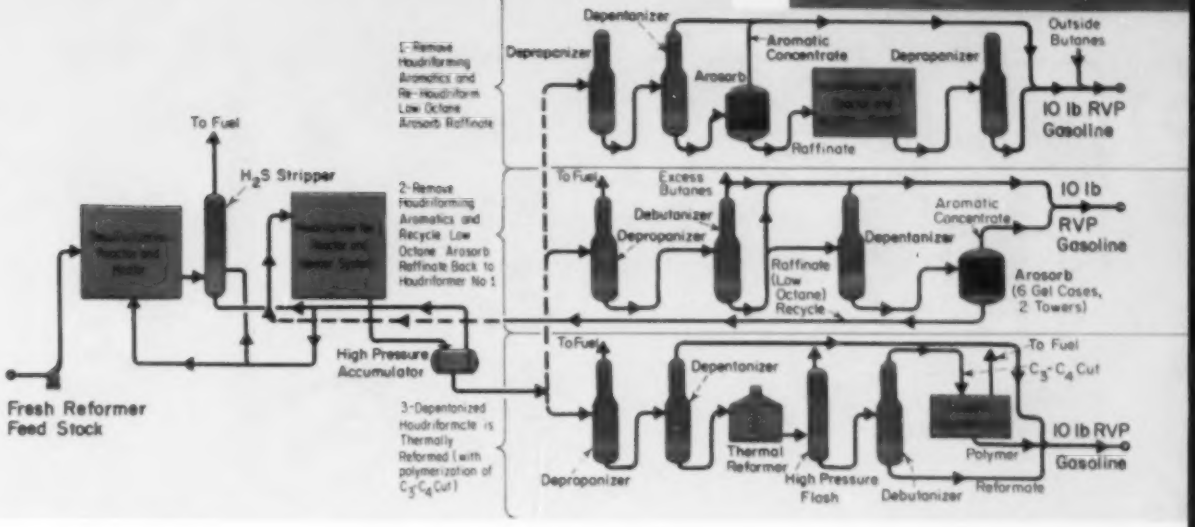
Economics—A 5000 b/sd Rexformer processing Mid-Continent full boiling straight-run gasoline to produce 101 F-1 clear octane reformate would cost about $300/bbl. capacity to install and about 36¢/bbl. feed to operate:

	Total
Erected cost (within battery limits)	$1,600,000
Operating Costs	
Operating labor @ $2.75/hr.	4.0¢/bbl.
Laboratory	1.0¢/bbl.
Utilities	
Fuel @ 15¢/million Btu	7.3¢/bbl.
Power @ 0.8¢/kwh	4.0¢/bbl.
Steam @ 30¢/thousand lb.	4.6¢/bbl.
Water @ 1¢/thousand gal.	1.4¢/bbl.
Catalyst	6.9¢/bbl.
Solvent	1.7¢/bbl.
Maintenance labor and materials[2]	2.8¢/bbl.
Insurance and property taxes[3]	1.9¢/bbl.
Total operating costs	35.6¢/bbl.

(1) 4300 b/sd fresh naphtha charge to reactor section
(2) 3% of investment per year
(3) 2% of investment per year
(4) Excludes royalty, depreciation, administration and overhead

Installations—None operating. Cities Service Oil Co. has announced plans to install a Rexformer at Ponca City, Okla.

Licensor—Universal Oil Products Co., 30 Algonquin Road, Des Plaines, Illinois.



Iso-Plus

Process Type—Combination process to produce F-1 clear octanes exceeding 100 utilizing a conventional Houdriforming unit in conjunction with one of three possible alternatives, including the use of an aromatics recovery unit or a thermal reformer.

Process Operation—Referring to the flow diagram and Tables 1 and 2, the operation of all three Iso-Plus alternatives is shown. All alternatives begin with mild conventional Houdriforming (described on pages 1178-79).

For the first alternative, reformate from the first Houdriformer is separated into a 91% aromatics concentrate by an Arosorb or other suitable aromatics recovery unit (described on pages 1198 to 1202) and an 81% paraffins concentrate, the latter being charged to the second Houdriformer. Blending second Houdriformer reformate, aromatic concentrate and light ends gives the 100 F-1 clear octane gasoline.

The second alternative is similar to the first except that Arosorb paraffin concentrate is recycled back to the first Houdriformer, eliminating the need for a second.

The third alternative does not have aromatics separation, but thermally reforms catalytic reformate, then adds catpoly gasoline from the thermal reformer off-gas olefins to meet 100 F-1 clear octane gasoline.

Operating Conditions—As shown in Table 1, Houdriforming is mild for all three alternatives.

Product—Gasoline Operation—All three alternatives can produce 100 F-1 clear octane. Paraffin recycle allows an 82.5% yield of 108 F-1 clear octane in the first alternative and reforming a larger paraffin recycle stream in the second alternative allows 105 F-1 clear octane. Data for 100 F-1 clear octane production for a typical 200/394°F. feed stock with an API of 51°, 0.125 wt.% sulfur, and an F-1 clear octane of 54.1—composed of 46% paraffins, 37% naphthenes and 17% aromatics—is given in Table 1.

Economics—Table 2 shows economic data for the three Iso-Plus alternatives for 6000 b/sd naphtha charge.

Installations—None operating yet.

Licensor—The Houdry Process Corp., Philadelphia, Pa.

Table 1 — Iso-Plus Yields and Streams

(to give 10 lb RVP, 100 F-1 clear octane gasoline for feed stock described under "Product-Gasoline Operation")

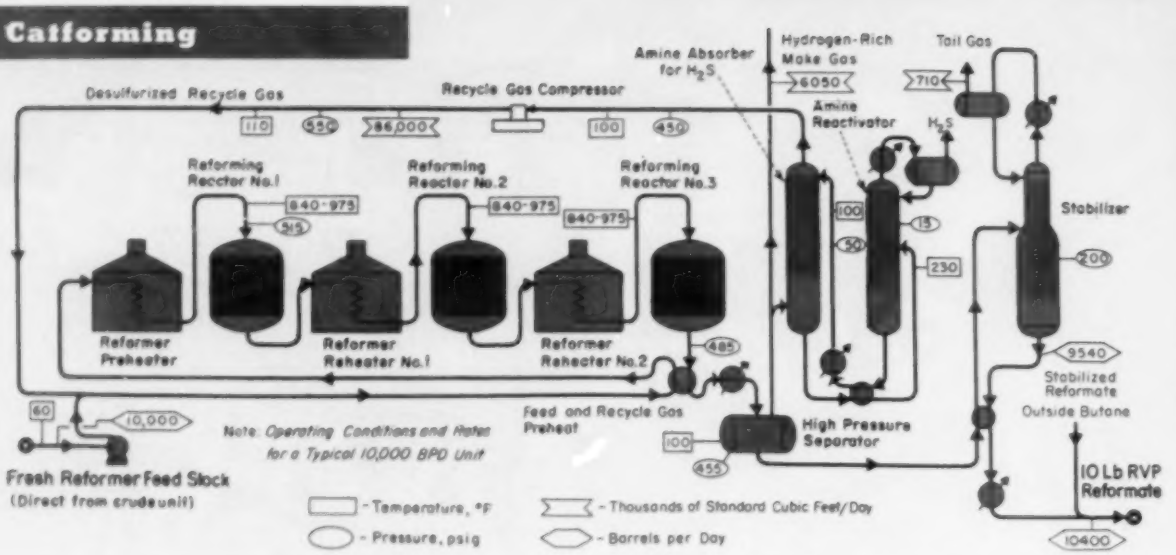
	Alt. 1	Alt. 2	Alt. 3
Total Houdriformer feed,	6,600	10,131[1]	6,600
C_5+ reformate yield,	5,900	8,753	5,900
Butanes yield,	271	574	271
Fuel gas (F.O.E.) yield,	422	818	422
C_5+ F-1 clear octane	87.0	83.0	87.0
Arosorb aromatic concentrate,	3,174	3,014	—
Arosorb raffinate,	2,429	3,531	—
Second pass reforming	catalytic	none	thermal
Reformate, C_5+,	1,932	—	4,807
Heavy polymer	—	—	33
Butanes	246	—	143
Butenes + propenes for cat. poly.	—	—	456
Fuel gas, F.O.E.	293	—	491
Reformate F-1 clear octane	81.0	—	99.6
Catalytic polymer gasoline	—	—	328
10 lb. RVP gasoline yield	5,993	5,751	5,671
Outside butanes used	73	−45	122

Note: All quantities in b/sd for a service factor of 0.909
[1] Includes 3,531 b/sd paraffin recycle from Arosorb

Table 2— Iso-Plus Economics for 6000 b/sd Unit

	Alt. 1	Alt. 2	Alt. 3
Investment (process equipment)	$3,183,000	$3,065,000	$2,680,000
Catalyst Inventory (@ $9.00/lb.), lb.	35,800	40,200	26,200
Silica gel Inventory (@ $0.30/lb.), lb.	310,000	363,000	—
Operating expenses, total, $/sd	23,904	24,120	23,055
Gasoline (10 lb. RVP, 100 F-1 clear octane) b/sd	5,447	5,228	5,155
cost, $/sd*	22,873	22,695	21,740

*Assuming credits for fuel gas (F.O.E.) @ $1.80/bbl. and excess butane @ $2.10/bbl., and charges for feed stock @ $3.36/bbl.



Catforming

Process Type—Catalytic reforming of petroleum naphthas with platinum-containing, regenerable catalyst through a series of fixed-catalyst-bed reactors.

Catalyst—Made in small cylindrical, gray pellets with a bulk density of about 40 lb./cu. ft. Composition is platinum on a silica-alumina base. Davison Chemical Co. (Div. of W. R. Grace and Co.) makes the catalyst under license from Atlantic Refining Co. Catalyst turnaround cost is about $4.00/lb.—including processing charges and used platinum credit. In loading, catalyst is simply poured into reactor top, and, in unloading, catalyst flows out through nozzles in the reactor bottom. Catalyst life is six months to a year up to the first regeneration. After activation, the catalyst platinum is in a reduced form. Using simple manufacturing variations allows tailoring catalysts for specific jobs, thus eliminating the need for chemical addition during reforming. Catalyst has a tolerance to water and nitrogen compounds, but is poisoned by copper, TEL and sodium hydroxide, with hydrogen sulfide depressing catalyst activity in a linear fashion.

Regeneration—Catalyst usually can be regenerated in situ 3 to 4 times with a shorter catalyst life between regenerations as burnings are carried out. Catalyst activity and selectivity return to the same initial values each time. Regeneration requires no special equipment and is done with a dilute air in steam mixture admitted to the first reactor—burning carbon off of the catalyst—and exhausting waste gas following the last reactor.

Feed Stocks for Gasoline—Naphtha feed stocks may have end boiling points up to 400°F. Full-boiling range naphthas may be charged to the Catformer since nitrogen compounds and water found in light cuts do not poison the catalyst.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production. Naphthenes can be converted to aromatics in the following magnitudes at typical operating conditions: C_6, 65-70%; C_7, 80-85%; C_8, 90-95%.

Table 1—Catforming of Different Naphtha Types

Feed Stock Source	East Texas*		Kuwait	
Gravity, °API	51.4		54.3	
ASTM, distillation, °F				
IBP	248		228	
10%	270		253	
30%	282		267	
50%	299		285	
70%	321		311	
90%	350		338	
EP	393		370	
F-1 clear octane	45.0		38.0	
F-1 + 3cc TEL	68.5		63.2	
RVP, psi	0		0.2	
Sulfur, wt.%	0.01		0.08	
Bromine No.	0		0.6	
Paraffins, vol.%	44.8		55.2	
Naphthenes, vol.%	42.8		28.4	
Aromatics, vol.%	12.8		16.2	
Reformate				
Reforming Severity	Low	High	Low	High
Yields, charge basis				
C_5+ reformate, vol.%	91.0	83.0	91.0	83.0
Butanes, vol.%	4.6	10.0	5.4	11.9
Propane, wt.%	1.9	3.6	2.4	4.6
Ethane, wt.%	0.22	0.49	0.29	0.68
Methane, wt.%	0.10	0.24	0.14	0.34
Hydrogen, wt.%	1.2	1.3	0.9	0.9
C_5+ Reformate				
ASTM distillation, °F				
IBP	145	133	105	98
10%	209	176	155	143
50%	288	284	262	255
90%	350	357	335	340
EP	395	408	371	378
Sulfur, wt.%	<0.001	<0.001	<0.001	<0.001
F-1, clear octane	80.2	94.4	72.4	87.1
F-1 + 3cc TEL	92.6	99.8	88.7	97.0
Gravity, °API	46.9	43.0	51.8	50.6
RVP, psi	2.0	3.5	2.2	3.9
10 lb. RVP reformate				
F-1, clear octane	82.3	94.7	75.2	87.9
F-1 + 3cc TEL	93.8	100.1	90.3	97.4
Yield, vol.% on charge	104.3	92.6	104.1	92.0

*The operations listed would be carried out at conditions approximating those of the flow diagram.

CATFORMER at Douglas Oil Co., Bakersfield, Calif.–2500 b/sd

Feed Stock Preparation—Catalyst poisons such as TEL, copper and sodium hydroxide do not occur naturally in naphtha and should be excluded from feed stock by observing good refinery "housekeeping" methods. Feed stock sulfur content versus process economics controls the need for pre-desulfurization or removing hydrogen sulfide from recycle gas with an amine scrubber. At present there are no pretreatment units in use on any Catformer unit.

Process Operation—Referring to the flow diagram–naphtha feed stock from the crude units joins with recycle hydrogen gas, the mix being heated and passed through the three reforming reactors and two interheaters. Third reactor effluent is cooled, separated into a hydrogen-rich gas stream–which can be passed through an amine scrubber for hydrogen sulfide removal prior to joining fresh feed stock as recycle gas–and a liquid stream which is then stabilized to produce a gasoline blending stock essentially free of sulfur.

Operating Conditions—Typical ranges of operating conditions are temperatures from 840-975°F. and pressures from 300-700 psig. As the catalyst slowly deactivates during use, activity loss is made up by increasing the reforming temperature until at 950-975°F. the catalyst is exhausted and requires regeneration. Higher pressures–up to 700 psig –are used to extend catalyst life when charging high boiling stocks, and lower pressures–around 300 psig–favor dehydrogeneration of naphthenes for aromatics production. An operating pressure of 500-600 psig is most economical for processing average crudes for octane improvement only.

Product—Gasoline Operation—Catformer reformate is essentially sulfur free following stabilization. By desulfurizing the hydrogen recycle gas, a feed stock containing 0.1 wt.% sulfur gives a recycle gas equivalent to that from a feed stock containing only 0.025 wt.% sulfur. No rerunning, sweetening or other finishing treatment is required on the reformate other than stabilization to prepare it for gasoline blending. Hydrogen gas production of 600 SCF/bbl. and 90-96% purity results from average feed stocks and reforming severities. Table 1 illustrates Catforming results for different naphtha types.

Product—Aromatics Operation—While no Catformer is used in this manner at present, the data in Table 2 indicates yields to be expected when operating for aromatics.

Equipment—An 18-8 stainless liner in the reactors to prevent scaling of this light gauge metal is the only high alloy used in the Catformer. Other alloy uses are dictated mainly by safety considerations in the problem of hydrogen blistering and embrittlement.

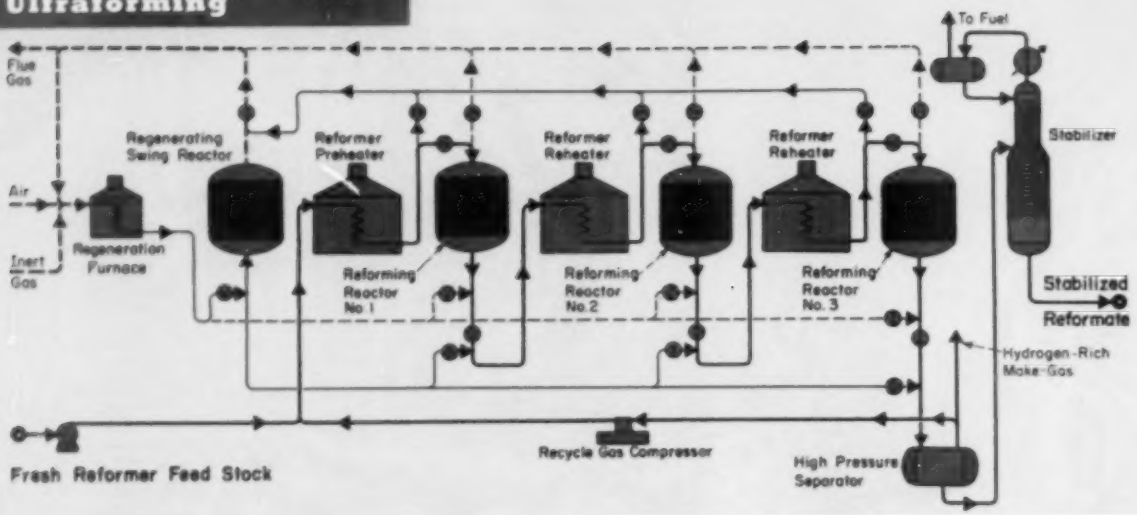
Economics—Catformer investment costs are $125-300/bbl. capacity, depending on size and specific design.

Installations—Fourteen Catformers are operating in the U.S. and Canada with a capacity range from 300 to 16,000 b/sd and a total capacity of 44,400 b/sd. Five units are licensed or under construction in the U.S. and Canada with a capacity range from 2000 to 13,000 b/sd and a total capacity of 18,500 b/sd. Six foreign units are licensed or under construction with a capacity range of 500 to 8,200 b/sd and a total capacity of 21,000 b/sd.

Licensor—The Atlantic Refining Co., Research and Development Dept., Development Div., Licensing Section, 2700 Passyunk Ave., Philadelphia, Pa.

Table 2—Catforming for Aromatics Production

Feed Stock analysis vol.%	Benzene Production	Toluene Production	Toluene-Xylene Production
Benzene	1.8	1.0	0.5
Toluene	0.1	2.6	3.8
106 MW Aromatics	0.1	0.1	1.9
120 MW Aromatics	0.0	0.0	0.0
Paraffins	47.0	45.9	39.1
Naphthenes	51.0	50.4	54.7
Total Aromatics	2.1	3.7	6.2
Debutanized Product analysis vol.%			
Benzene	24.7	8.9	3.2
Toluene	5.9	25.9	21.1
106 MW Aromatics	0.1	5.5	23.0
120 MW Aromatics	0.0	0.1	2.2
Yield Structure			
C_5+ yield vol.%	91.9	90.7	90.7
C_4's vol.%	2.4	1.9	1.7
Propane, wt.%	1.6	1.5	0.9
Ethane, wt.%	0.33	0.23	0.05
Methane, wt.%	0.27	0.23	0.06
Hydrogen, wt.%	2.1	2.2	2.6



Ultraforming

Process Type—Catalytic reforming of petroleum naphthas with platinum-containing, regenerable catalyst through a series of fixed-catalyst-bed reactors.

Catalyst—Platinum-containing catalyst developed jointly by Standard Oil Co. (Ind.) and American Cyanamid Co.—now supplied by American Cyanamid Co. Catalyst composition is 0.6% platinum on an alumina support. Tests indicate a catalyst life above 100 barrels of feed per pound of catalyst. Replacement cost is about $4.00/lb. including credit for platinum in used catalyst.

Regeneration—Full catalyst activity is restored with in situ regeneration by burning carbon off of the catalyst with

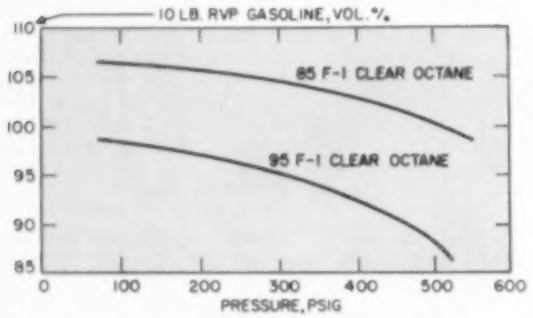


FIG. 1—Effect of pressure on gasoline yield (Mid-Continent naphtha)

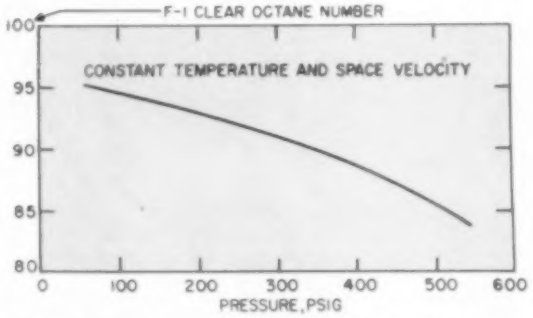


FIG. 2—Effect of pressure on octane yield (Mid-Continent naphtha)

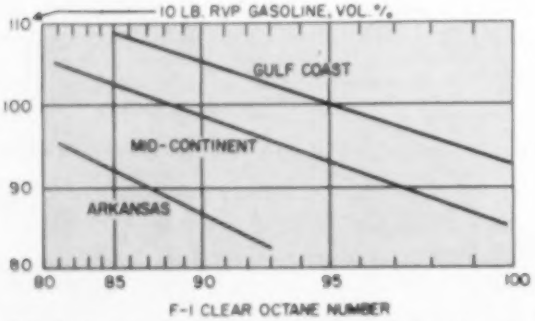


FIG. 3—Gasoline yields from different naphthas—for data in Table I.

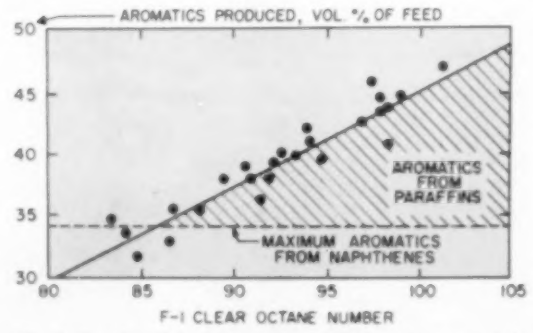
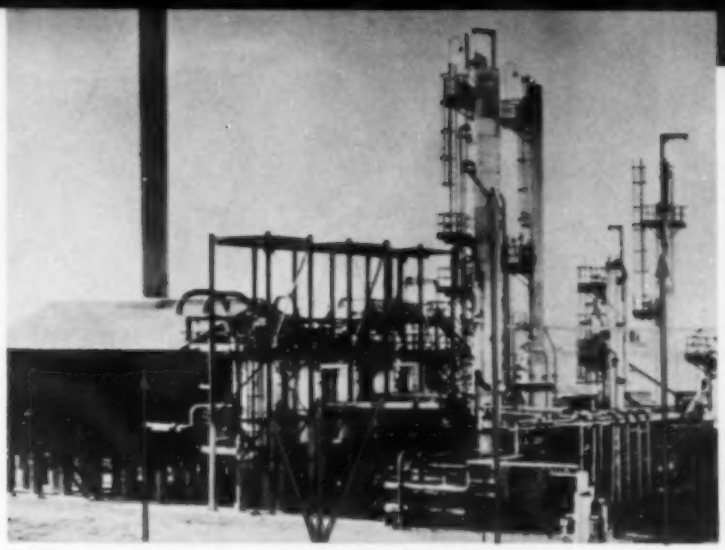


FIG. 4—Paraffin dehydrogenation (Mid-Continent naphtha with 40% naphthenes)



ULTRAFORMER at Standard Oil Co. (Ind.), Casper, Wyo.–3750 b/sd

FURNACES REACTORS FEED PREPARATION PRODUCT RECOVERY

an air-inert gas mixture. Regeneration can be conducted without a shutdown by means of a "swing" reactor (the fourth reactor) so that three reactors are always onstream while the fourth is idle or being regenerated.

Feed Stocks for Gasoline—Can be naphthas that vary widely in character. It is preferable that cracked stocks be desulfurized before charging to the reformer.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production.

Feed Stock Preparation—Desulfurization prior to the reaction system is desirable when charging high-sulfur crudes.

Process Description—Referring to the flow diagram–the feed stock and hydrogen-rich recycle gas are heated to reaction temperature, then passed through the three onstream reactors and two interheaters. Effluent from the third reactor is cooled, then separated into a liquid stream and a hydrogen-rich gas. The liquid is then stabilized to the desired vapor pressure and is ready for gasoline blending. Separator gas is recycled to mix with fresh feed before the reforming reactors. When catalyst activity in a reactor drops, the reactor is isolated from the process system and replaced by the "swing" reactor. The isolated reactor is then regenerated and placed back onstream, leaving the swing reactor free for use in regenerating another reactor.

Operating Conditions—The preferred range of reactor conditions is 200-300 psig and 900-970°F. with a space velocity of about 1-4. The low pressure operation of this process gives large aromatic, hydrogen and gasoline yields. The effect of pressure on octane and gasoline yields are shown in Figs. 1 and 2 for a Mid-Continent naphtha.

Product—Gasoline Operation—High F-1 clear octanes result from reforming feed stocks high in paraffins as well as those high in naphthenes. Commercial units now onstream have operated at octane levels in excess of 100 F-1 clear octane with Gulf Coast naphthas, and in excess of 95 F-1 clear octane with highly paraffinic (70-80%), low naphthenic (10-20%) naphtha. Table 1 presents data for the reforming of feed stocks from different sources, and Fig. 3 gives a graphical representation of octane versus 10 lb. RVP gasoline yields for the data in Table 1.

Product—Aromatics Operation—The low operating pressures of Ultraforming encourage the formation of aromatics during the reforming process. Fig. 4 illustrates aromatization of naphthenes and paraffins for a Mid-Continent naphtha containing 40% naphthenes.

Equipment—No information furnished concerning the use of special equipment or alloys.

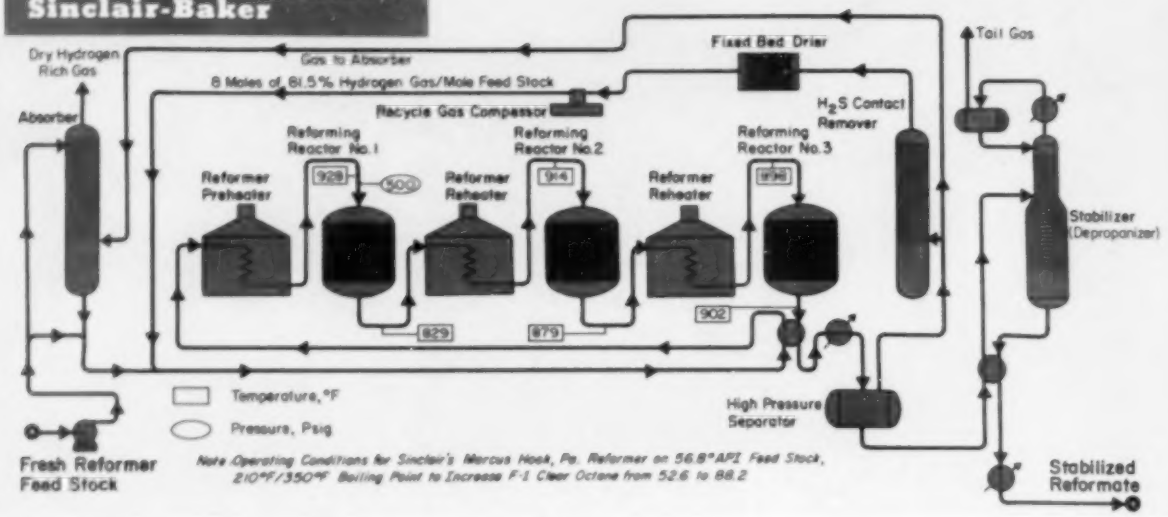
Economics—Investment for an Ultraformer may be minimized by eliminating the swing reactor and using other arrangements which have been developed for effecting the required regeneration with a minimum of offstream time.

Installations—Five Ultraformers are now in operation in the U.S. and Canada with capacities from 3750 to 21,000 b/sd, and a total capacity of 60,100 b/sd. It is expected that an additional three units with a total capacity of 28,600 b/sd will be onstream by the end of August, 1955. Six more Ultraformers with capacities from 2400 to 20,000 b/sd and a total capacity of 54,000 b/sd have been announced as licensed or under construction. For a detailed tabulation of units, see pp. 1166-69.

Licensor—Standard Oil Co. (Indiana), Development and Patent Dept., 910 S. Michigan Ave., Chicago 80, Ill.

Table I — Ultraforming of Various Naphthas

Feed Stock Source	Gulf Coast		Mid-Continent				Arkansas	
ASTM distillation, °F.								
IBP	202		206				149	
10%	250		237				172	
50%	305		274				244	
90%	356		324				322	
EP	394		361				377	
F-1 clear octane	59.4		44.5				45.3	
Composition, vol.%								
Paraffins	26.0		50.0				77.0	
Naphthenes	55.5		41.5				15.0	
Aromatics	18.5		8.5				8.0	
Reformate								
Pressure, psig	300		200		300		300	
Yields, charge basis								
C_5 + vol.%	91.8	83.8	90.5	84.1	89.9	82.8	84.5	80.0
Butanes, vol.%	2.7	6.2	2.0	4.4	3.1	5.5	7.1	9.3
Dry Gas, wt.%	3.4	7.2	3.3	6.7	4.8	8.4	7.5	9.8
Hydrogen, SCF/bbl.	900	1100	1080	1260	970	1150	540	590
C_5 + reformate								
F-1 clear octane	90	100	85	95	85	95	85	90
RVP, psi	2.0	3.3	2.1	2.6	2.4	2.8	5.4	6.0
10 lb. RVP gasoline								
F-1 clear octane	90	100	85	95	85	95	85	95
vol.% of feed	105.7	93.2	104.5	95.2	103.1	93.3	91.8	85.7


Dry Hydrogen Rich Gas
Gas to Absorber
8 Moles of 81.5% Hydrogen Gas/Mole Feed Stock
Fixed Bed Drier
Tail Gas
Absorber
Recycle Gas Compressor
H_2S Contact Remover
Reforming Reactor No.1
Reforming Reactor No.2
Reforming Reactor No.3
Reformer Preheater
Reformer Reheater
Reformer Reheater
Stabilizer (Depropanizer)
Temperature, °F
Pressure, Psig
High Pressure Separator
Fresh Reformer Feed Stock
Stabilized Reformate
Note: Operating Conditions for Sinclair's Marcus Hook, Pa. Reformer on 56.8° API Feed Stock, 210°F/350°F Boiling Point to Increase F-1 Clear Octane from 52.6 to 88.2

Sinclair-Baker

Process Type—Catalytic reforming of petroleum naphthas with Sinclair-Baker "RD-150" platinum-containing, regenerable catalyst through a series of fixed-bed reactors.

Catalyst—Developed jointly by Sinclair Development Co. and Baker and Co.—the latter manufactures the catalyst in their Newark, N. J., plant—and is called "RD-150." Catalyst contains about 0.6 wt.% platinum on alumina and has a life of from 40 to 200 barrels of feed per pound of catalyst. The high platinum content is claimed to aid regenerability and poison resistance.

Regeneration—In situ regeneration of three reactors—by burning carbon from catalyst with an air-inert gas stream—requires 24-48 hours with 7-20 regenerations economically feasible. Present practice is for intermittent regeneration, but using regeneration during processing is feasible.

Feed Stocks for Gasoline—In general include straight-run stocks with boiling points from 200° F. initial to 400° F. end, and hydrogenated cracked naphthas.

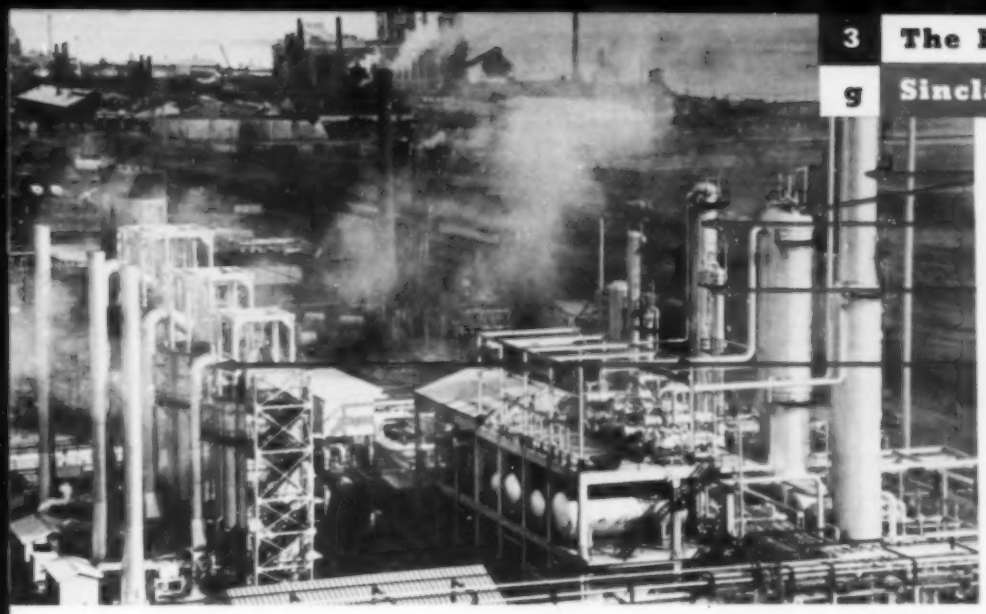
Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production.

Feed Stock Preparation—Light naphthas having poor octane yields and heavy naphthas shortening catalyst life or producing high gasoline boiling points can be eliminated from feed stock, depending on the economics of the operation. Olefins in cracked stocks should be saturated with hydrogen over a cobalt-molybdena catalyst prior to reforming—which also removes sulfur and some catalyst poisons. Glycol-amine scrubbing of recycle gas is adequate for low sulfur stocks.

Process Operation—Referring to flow diagram—after pretreatment—feed stock naphtha is fed as lean oil to absorber to recover butanes and heavier from net hydrogen-rich make-gas. After absorption, naphtha combines with hydrogen-rich recycle gas, and the mixture is heated to reaction temperature, then sent through the three reforming reactors and two interheaters. Third reactor effluent is cooled, then separated into a hydrogen-rich gas stream—part being recycled and part going to the absorber—and an unstabilized liquid reformate stream. The liquid stream is stabilized to the desired vapor pressure. No rerun is required.

Table 1 — Reforming at 200 psig with RD-150

Feed Stock Source	Mid-Continent		Venezuela		Kuwait	
Gravity, °API	54.1		48.6		54.0	
ASTM distillation, °F						
IBP	236		252		240	
10%	257		273		283	
50%	291		306		310	
90%	341		358		337	
EP	373		385		355	
F-1 clear octane	36.5		51.0		29.6	
F-1 + 3 cc TEL	61.0		73.0		52.5	
Sulfur, wt. %	0.021		0.032		0.087	
Naphthenes, vol. %	43.2		43.0		19.4	
Aromatics, vol. %	7.7		22.9		14.7	
Paraffins, vol. %	48.8		33.8		65.1	
Reformate						
Reforming severity	Low	High	Low	High	Low	High
Yields, charge basis						
C_5+, vol. %	87.8	83.3	91.8	86.8	86.8	81.2
Butanes, vol. %	2.8	4.2	1.5	2.9	3.2	4.9
Propane, wt. %	2.6	3.6	0.8	2.0	2.1	3.4
Ethane, wt. %	1.8	2.1	0.6	1.3	1.3	2.4
Methane, wt. %	0.7	0.9	0.5	0.8	0.4	1.1
Hydrogen, CF/bbl.	880	1150	930	830	730	875
C_5+ reformate						
ASTM dist., °F						
IBP	130	126	190	150	...	...
10%	209	207	252	242	177	...
50%	285	288	303	298	270	...
90%	360	363	370	378	362	...
EP	448	457	437	455	419	...
Sulfur, wt. %	0.005	0.005	0.005	0.005	0.004	0.004
F-1 clear octane	85.0	95.0	85.0	95.0	85.0	95.0
F-1 + 3 cc TEL	94.4	99.7	95.2	99.0	93.5	99.2
Gravity, °API	44.9	42.3	41.9	39.6	50.9	...
10 lb. RVP gasoline						
F-1 clear octane	85.8	94.6	86.1	94.6	85.9	94.7
F-1 + 3 cc TEL	95.3	99.9	96.2	99.4	94.5	99.4
Vol. % of charge	102.0	94.8	107.5	100.7	100.0	92.8
Outside C_5's vol. %	9.8	7.9	14.2	11.0	10.0	6.7



SINCLAIR-BAKER unit at Sinclair Refining Co., Marcus Hook, Pa. —16,000 b/sd

Operating Conditions—The preferred range of reactor conditions is 200-750 psig, 825-950° F., and based on fresh feed, 1-5 weight hourly space velocity and 3-10 molal recycle gas ratio. Continuous operation at around 500 psig is attractive when producing 80-90 F-1 clear octane reformate (though regenerative operation allows higher than normal space velocities). Regenerative operation at around 200 psig is usually preferable for reformates above 90 F-1 clear octane—since low pressure operation tends to shorten catalyst life—depending to some extent on feed paraffin content.

Product—Gasoline Operation—Table 1 presents examples of reformate with naphthas from different crude sources.

Product—Aromatics Operation—Table 2 shows the effective isomerization of a C_7 naphthene cut to aromatics, and Table 3 illustrates aromatic production for selected cuts.

Equipment—Under normal circumstances with a Mid-Continent feed stock, no special provisions for alloy steel need be made, with the possible exception that a small amount of chrome may be desirable in the heater tubes, and alloys for equipment in high temperature hydrogen service. Reactor vessels are of low carbon steels with internal insulating refractory to maintain shell temperatures below the level at which hydrogen attack might occur.

Economics—Average catalyst cost is 3-10 cents per barrel of reactor feed, depending upon feed stocks and octane requirements. A breakdown of typical operating costs is given in Table 4.

Installations—At present there are six U. S. units operating using RD-150 catalyst. They have capacities of 3000 to 20,000 b/sd and a total capacity of 62,000 b/sd. Eight more units are planned or under construction; projected capacities for four total 59,000 b/sd.

Licensor—Licensing arrangements for use of Sinclair-Baker RD-150 catalyst can be made through Baker and Co. or the M. W. Kellogg Co.

Table 3—Reforming for Aromatics

Feed Stock Source	—Venezuela—			—California—			Mid-Cont.
Fraction	C_6	C_7	C_8	C_6	C_7	C_8	C_6
Boiling points, °F							
Initial	148	190	248	161	192	245	162
End	248	265	295	195	215	266	180
Naphthenes, vol. %	20.1	32.4	31.4	87.8	62.5	59.0	70.7
Aromatics, vol. %	8.4	18.9	21.5	2.6	3.7	4.8	3.6
Paraffins, vol. %	71.5	48.7	47.1	9.6	33.8	36.2	25.7
Aromatic Product							
Yields on charge							
Benzene, vol. %	13.7	1.5	0.5	57.0	0.8	0.3	50.0
Toluene, vol. %	8.2	28.2	4.0	2.7	46.2	1.7	1.6
Xylenes, vol. %	..	15.2	33.4	..	8.6	30.4	..
C_9+ aromatics, vol. %	..	2.4	18.3	..	1.0	7.6	..
C_4's, vol. %	10.3	8.2	7.6	5.4	8.4	4.9	12.2
$C_3 + C_7 + C_{10}$ wt. %	8.6	5.2	5.7	4.2	5.8	2.2	13.1
Hydrogen, CF/bbl.	410	1000	1360	2110	2000	1350	1500
Paraffin cyclization, %[1]	..	10	24	..	25	19	..

[1] Minimum cyclization assuming naphthenes converted to aromatics only.

Table 2—Isomerization of Naphthenes in C_7 Cut

(Using RD-150 catalyst at 900° F and 300 psig.)

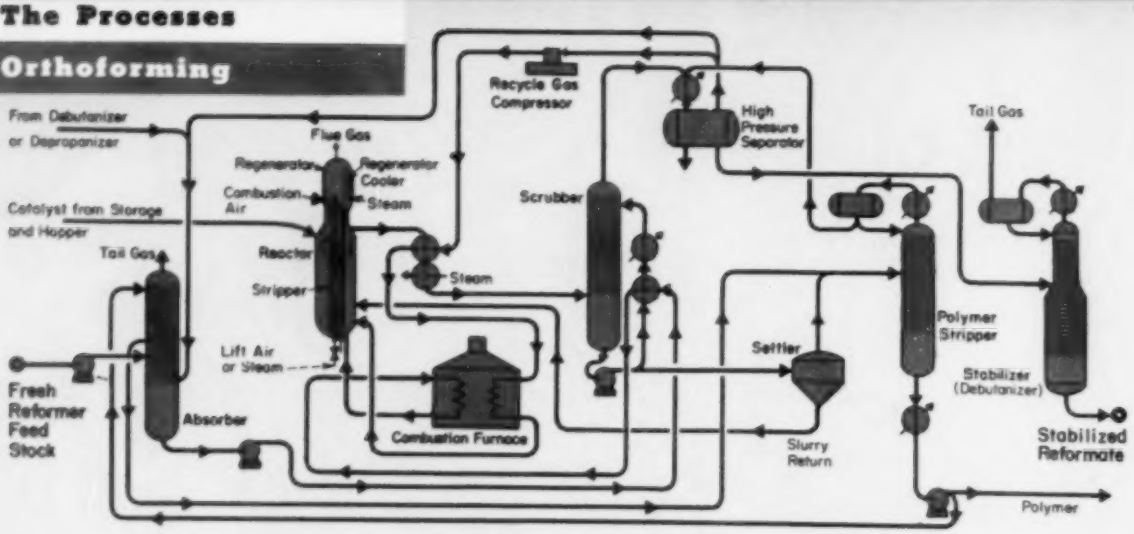
	Feed stock analysis, vol. %	Product analysis vol. % fresh feed	Naphthene* analysis, %
Paraffins	37.0	31.2	..
Olefins	0.0	0.8	..
Naphthenes	63.0	7.3	..
Cyclohexane	..	..	2.3
1,1-dimethylcyclopentane	..	..	12.9
1,2-dimethylcyclopentane	..	..	45.0
1,3-dimethylcyclopentane	..	..	39.8
Aromatics	0.0	44.4	..

* Composition of naphthenes in fresh feed stock

Table 4—Typical Operating Costs

(10,000 b/sd Gulf Coast unit, not including prefractionation)

	¢/bbl. feed
Operating and supervision	2.6
Repair labor	4.0
Repair material	2.2
Misc. operating supplies	0.2
Utilities	
Steam—High pressure @ 30¢/thousand lb.	0.9
Steam—Exhaust @ 15¢/thousand lb.	1.3
Power @ 0.8¢/kwh	0.8
Water @ 1¢/thousand gal.	1.0
Fuel @ 15¢/thousand Btu	2.2
Total direct operating cost (excluding catalyst)	15.2



Orthoforming

Process Type—Catalytic reforming of petroleum naphthas with molybdena-alumina catalyst through a single fluidized solids-catalyst-bed reactor – with integrated regenerator – and continuous regeneration. This process is primarily a modification of the basic fluid Hydroforming process licensed by Esso Research and Engineering Co. and M. W. Kellogg Co. Orthoforming design allows "in-line, side-by-side" catalyst handling between reactor and the regenerator.

Catalyst—Made by impregnating a precipitated alumina gel with a molybdenum salt solution to produce a material containing approximately 10% MoO_3–the active catalyst ingredient. A typical Roller analysis shows 45 wt.% of 80+ material and less than 3 wt.% of 0-20 micron particle size. Fluidized density is roughly 35-45 lb./cu. ft. No protection against typical contaminants such as sulfur, arsenic, etc. is needed.

Regeneration—Catalyst regeneration is continuous. During regeneration coke and sulfur are burned from the catalyst, thus restoring catalyst activity and eliminating corrosion possibilities at subsequent points in the system.

Feed Stocks for Gasoline—Straight-run, cracked, or mixed origin feed stocks, with boiling ranges including those of gasoline and kerosine, may be processed. Sulfur and olefins have no great effect on reformer operations.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production. In a typical fluid Hydroformer unit–generally similar to an Orthoformer–the feed stock consisted of a naphthene-rich fraction with an 80°F. spread between initial and boiling points, producing an aviation blending agent rich in aromatics.

Feed Stock Preparation—Feed preparation may be incorporated – from economic considerations, such as boiling range–but the relative insensitivity of the catalyst to normal poisons in stock virtually eliminates the need for other pretreatment facilities.

Process Operation—Referring to the flow diagram–all dense phase fluidized catalyst flow is accomplished in straight vertical lines without bends or offsets. Catalyst flow is from a point near the top of the reactor catalyst bed, through slots into and down the stripper, and then up through the catalyst riser to the regenerator. The regenerated catalyst then flows downward through the regenerated catalyst standpipe to the bottom of the reactor bed. Spent catalyst flow into the riser and regenerated catalyst flow out of the regenerated catalyst standpipe is in each case controlled by special plug valves similar to those developed for Orthoflow F.C.C. units. Preheated naphtha and recycle gas enter at the base of the reactor with reaction products leaving the top of the reactor section. After being cooled, the reaction products pass through the scrubber and quench drum with the bottoms going to the catalyst settler followed by a polymer removal column, and the overhead going to a high pressure separator. Separator gas is recycled to the feed stock absorber and then the reactor and separator liquid is stabilized to produce finished reformate.

Operating Conditions—Reformate octane level increases with rising temperature and increased catalyst circulation rate. An increase in reactor catalyst-bed size–corresponding to a decrease in space velocity–also increases reformate octane. Overall economic considerations tend to fix pressures at 200-250 psig. Variations in feed stocks, olefin contents, and octane requirements can be compensated for readily by adjustments in operating conditions–such as in the case of sudden addition of 20% cracked material to virgin feed stocks. Operating conditions for aromatic-rich fractions for aviation gasoline are not greatly different from normal gasoline operations to a comparable octane. Operations for producing specific aromatic compounds are feasible through selection of highly naphthenic feed stocks. Table I presents pilot plant operations–typical of actual commercial operations–for reforming Middle East virgin heavy naphtha.

Product—Gasoline Operation—Debutanized reformate octanes of 98 F-1 clear from Kuwait virgin heavy naphtha, or 100 F-1 clear from East Texas virgin heavy naphtha are possible. Yield-octane relationships to be expected from

ORTHOFORMER at Standard Oil Co. (Ind.), Whiting, Ind.–25,000 b/sd

these feed stocks are shown in Table 2. In addition, Table 1 gives detailed operating results for the reforming of Middle East virgin heavy naphthas. Approximately 600 standard cubic feet of hydrogen per barrel of feed is produced by a typical Orthoformer operating for motor gasoline at a 90 F-1 clear debutanized octane level.

Product—Aromatics Operation—Specific information is not available on aromatics from Orthoforming.

Economics—Installation costs are $175-400 per barrel of feed stock capacity for capacities of 3500-35,000 b/sd. Feed stock characteristics, desired octane level, equipment specifications, etc. control exact investment costs. Direct operating costs varying from 20-35¢/bbl., including catalyst cost, but not including fixed charges, taxes, insurance, etc., as given in Table 3. Licensing fees are on an optional paid-up or continuing basis.

Equipment—Orthoforming catalytic reforming process differs from conventional fluid Hydroforming in that for Orthoforming, the reactor, stripper and regenerator are integrated into a single vessel by means of a novel design of K-welded internal head common to the regenerator and the reactor, made without impairment of shock and fatigue resistance. All external catalyst transfer lines are eliminated and catalyst flow occurs in straight, internally located lines.

Installations—One Orthoformer, 25,000 b/sd capacity, has been built for Standard Oil Co. (Ind.) at their Whiting, Ind., refinery. Onstream date for this unit was April 2, 1955.

Licensor—The M. W. Kellogg Co., 225 Broadway, New York, N. Y.

Table 1—Orthoforming Middle East Virgin Heavy Naphtha

(pilot plant results)

Feed Stock properties		
Gravity, °API		52.8
ASTM distillation, °F.		
IBP		250
10%		293
50%		323
90%		360
EP		385
F-1 clear octane		25.9
F-1 + 3cc TEL		51.1
Reformate		
Yields, charge basis	Case A	Case B
C_5+ reformate, vol.%	76.0	70.5
C_4's, vol.%	9.0	10.7
Dry gas, wt.%	12.3	15.6
F-1 clear octane (C_5+)	93.0	98.0
Operating Conditions		
Pressure, psig	200-250	200-250
Reactor temperature, °F.	890-920	900-935
Recycle gas rate, SCF/bbl.	3500-6000	4000-6000
Catalyst/oil wt. ratio	0.5-1.0	0.5-1.5

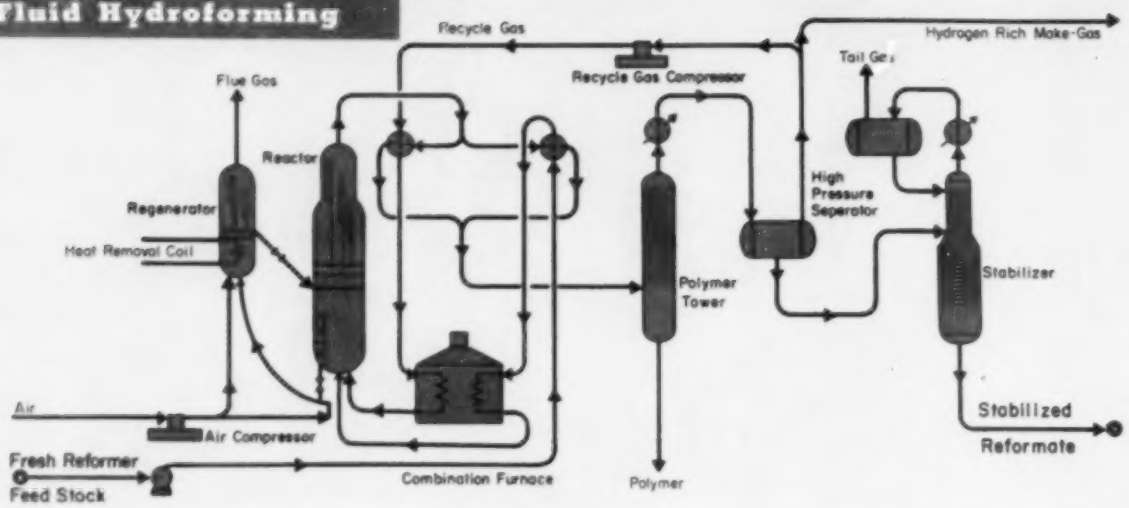
Table 2—Orthoforming East Texas and Kuwait Virgin Heavy Naphthas

Reformate Data	East Texas Naphtha			Kuwait Naphtha		
F-1 clear octane (C_5+)	85	93	100	85	93	98
Yield, C_5+, vol.% feed	87.5	83.4	75.7	81.1	76.0	70.5
C_4's, vol.% feed	3.8	5.0	7.5	7.7	9.0	10.7
Dry gas, wt.% feed	5.3	8.3	12.9	9.0	12.3	15.6

Table 3 — Orthoforming Operating Costs

10,000 b/sd unit — Gulf Coast price structure

	¢/bbl. feed
Operating labor	3.0
Steam @ 35¢/1000 lbs.	1.0
Power @ 0.8 ¢/kwh	3.0
Cooling water @ 1¢/1000 gals.	1.0
Maintenance	4.0
Catalyst @ 85¢/lb.	5.0
Fuel @ 20¢/million Btu	6.0
Total direct operating cost	23.0



Fluid Hydroforming

Process Type—Catalytic reforming of petroleum naphthas with molybdena-alumina catalyst through a single fluidized solids-catalyst-bed – with continuous regeneration in a separate regenerator.

Catalyst — Consists of 10% molybdena on alumina manufactured in the U. S. by National Aluminate Co. – abroad by Kohlnklijke Zwavelzuurgabrieken v/h Ketjen N.U.P. (Holland). Catalyst is a white powder with a bulk density of 55 lb/cu. ft. and a replacement cost of $0.60/lb. Average catalyst make-up needed is one-tenth pound per barrel of feed processed. Trace materials such as arsenic, iron, nitrogen or other elements do not poison or depress catalyst activity.

Regeneration — Carbon deposited on the catalyst during operation is removed by withdrawing a portion of the catalyst recirculating in the reactor and burning the carbon off in a separate regenerator using straight air with no preheat. Regeneration temperature is 1100-1150°F., pressure 200-250 psig. Carbon removal is 100%. Heat liberated by catalyst carbon combustion can be used to generate steam or preheat reactor feed. Molybdenum sulfide – formed by the reaction of catalyst molybdenum oxide and feed stock sulfur–is reoxidized to molybdenum oxide with the release of SO_2 during regeneration.

Feed Stocks for Gasoline — Can be paraffinic, naphthenic, sweet or sour naphthas, cracked naphtha or coker naphtha. There is no lower limit to feed stock initial boiling point – though it is harder to reform feed stocks with low IBP. The practical upper limit to feed stock end boiling point is about 430°F. High olefin contents in feed stocks result in a higher rate of carbon deposition on the catalyst – a condition compensated for by a proportionate increase in the amount of catalyst withdrawn from the reactor for regeneration.

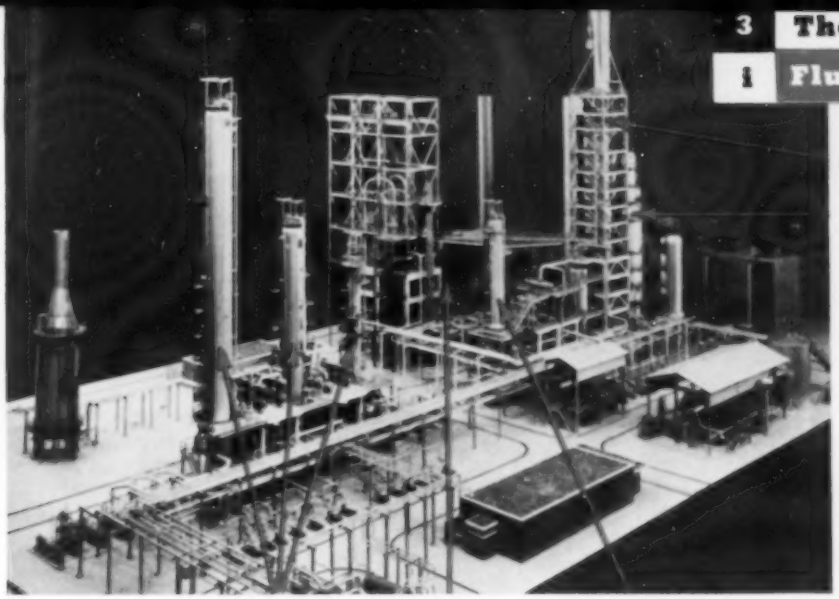
Feed Stocks for Aromatics—Though specific information is not available for producing aromatics, the general approach of tailoring the feed stock to a narrow cut for optimum aromatics production would apply.

Feed Stock Preparation — Normal feed stock impurities do not need to be removed. High sulfur blends containing 60% cracked naphthas have been processed without feed pretreatment, as have naphthas containing up to 0.5% sulfur. Olefin saturation is not necessary as the resulting higher rate of carbon laydown on the catalyst is allowed for by adjusting the regeneration rate.

Process Operation — Referring to the flow diagram – fluidized catalyst circulates continuously between the reactor and the regeneration. Preheated feed stock and recycle hydrogen enters the reactor bottom, meeting an isothermal bed of fluidized catalyst. Reaction products leave the reactor top, are cooled, then separated into a gas and a liquid phase. The hydrogen-rich gas phase recycles to the reactor. The liquid phase has entrained catalyst removed and polymer stripped out, then is stabilized to the desired vapor pressure to produce gasoline blending stock.

Operating Conditions — Typical reactor operating conditions are temperatures of 900-940°F, pressures of 200-250 psig and recycle gas rates of 4000-6000 SCF/bbl. feed. Catalyst regeneration is at 1100-1150°F and 200-250 psig. Naphtha feed stock is heated to a maximum of 1000°F, prior to the reactor, furnishing about 25% of the heat of reaction. Higher temperatures would increase reforming yield losses due to thermal cracking of the feed stock. Recycle tail gas – heated to about 1200°F – furnishes about 55% of the heat of reaction. Temperatures above 1200°F for the recycle gas would cause thermal degradation of the hydrocarbons in the recycle gas. The remaining heat of reaction – about 20% – is carried into the reactor by the catalyst circulating between the regenerator and the reactor. There is a limit to this catalyst circulation rate since it tends to promote carbon producion which would increase compressed air requirements for the catalyst regenerator.

Product — Gasoline Operation — Can produce gasolines in the 90-100 F-1 clear octane range from a wide variety of feed stocks. High paraffin stocks are more difficult to reform – as is true for other processes. Reformates from high



FLUID HYDROFORMER
(scale model)
for Esso Standard Oil Co.,
Baton Rouge, La.–27,800 b/sd

sulfur crudes are essentially free of sulfur. The potential octane ceiling is stated to be higher than for other known methods of reforming. Examples for reforming virgin Louisiana and Arabian stocks, and a California mixture of virgin and cracked stocks are given in Table 1.

Product — Aromatic Operation — Information concerning the production of specific aromatics is not available for release, but typical degrees of aromatization of paraffins and naphthenes during the production of motor gasolines are:

Octane No.	Conversion to aromatics, % Naphthenes	Paraffins
85	68	12
90	75	14
95	81	17
98	88	19

By-product hydrogen produced during aromatics operation is 500-900 cu. ft./bbl. feed having 55-85% purity.

Equipment — The efficiency of heat transfer and related items have been so improved for the Model I Fluid Hydroformer, that plans for the Model II – announced last year as costing less to build and operate due to the circulation of inert pellets along with the fluidized catalyst to improve heat transfer from the regenerator to the reactor – have been postponed in favor of continuing the Model I.

Economics — Typical process requirements and reactor steel are presented in Table 2 for reforming a 250-325°F West Texas virgin naphtha to produce a 92 F-1 clear octane reformate in a 22,200 b/sd Fluid Hydroformer. Data for investment and operating costs will vary, depending on unit capacity, site facilities, construction standards, feed stock nature and reformate octane desired.

Installations — Five Fluid Hydroformers are operating in the U. S. with capacities from 2000 to 27,000 b/sd, and a total capacity of 84,000 b/sd. Two more units are projected in the U. S. with capacities of 7,200 and 19,000. Six foreign units are operating or projected with capacities from 4700 to 15,000 b/sd, and a total capacity of 59,900 b/sd. For a detailed tabulation of installations, see pp. 1166-69.

Licensor — Process Licensing Division, Esso Research and Engineering Co., 15 West 51st St., New York 19, N. Y. and the M. W. Kellogg Co., 225 Broadway, New York 7, N. Y.

Table 1 — Fluid Hydroforming of Various Naphthas

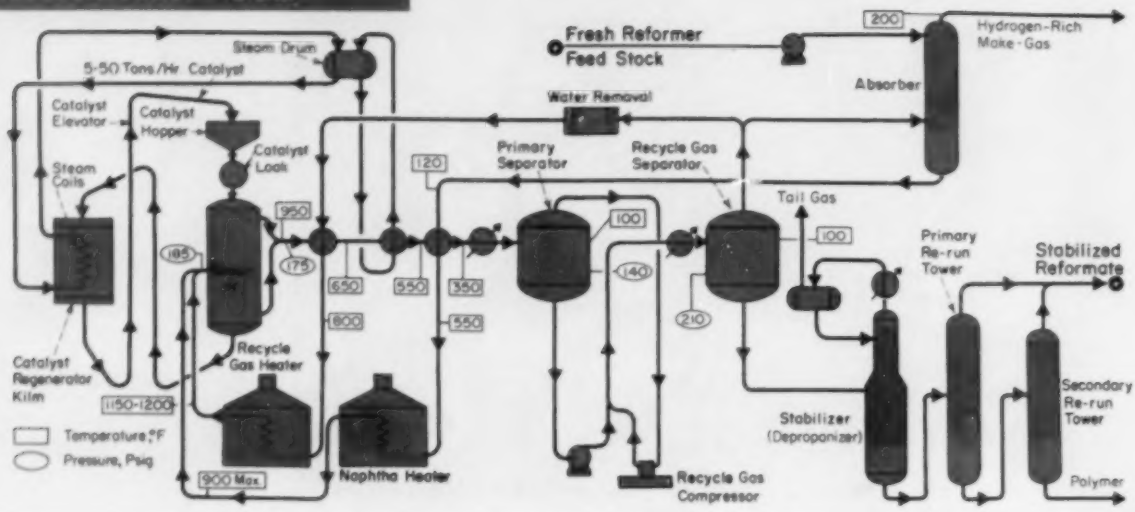
Feed Stock Source	Virgin Louisiana	Virgin Arabian	Mixed California[1]
Initial ASTM boiling point, °F	205	220	240
End ASTM boiling point, °F	325	345	415
Sulfur, wt. %	0.005	0.025	0.51
Paraffins, vol. %	44	70	—
Bromine number	—	—	37
Reformate			
Yields, charge basis:			
C_5^+, vol. %	80.5	73.0	83.5
C_5's, vol. %	6.4	9.6	3.9
C_5's, minus, vol. %	9.2	13.9	9.3
Carbon, wt. %	0.9	1.5	2.3
C_5^+ reformate			
F-1 clear octane	95	95	95
Gravity, °API	45.2	49.0	39.4
RVP, psi	3.4	6.0	—
Volatility, ASTM % at:			
212°F	20	28	23.5
257°F	58	59	53.0
302°F	88	88	83.0
356°F	98	98	—
Sulfur, wt. %	0.001	0.001	0.0014

[1]38% virgin California naphtha, 19% low quality thermal cracked naphtha and 43% heavy catalytic naphtha.

Table 2 — Process Requirements for Fluid Hydroforming with 22,200 b/sd Unit

Compressor, brake horsepower	5,500
Air	3,100
Recycle	2,400
Furnaces, total heat absorbed (106 Btu/hr.)	125
Heat transfer surface sq. ft.	50,000
Reactor steel, lb.	620,000
Utilities – reforming section	
Power, kw	4,900
Cooling water, gpm	5,900
Steam, net lb/hr	–1,500

(Feed stock is a 250-325°F West Texas virgin naphtha producing 92 F-1 clear octane reformate.)



Thermofor Catalytic Reforming

Process Type—Catalytic reforming of petroleum naphthas with synthetic, chromia-alumina bead catalyst through a single, moving-catalyst-bed reactor with continuous catalyst regeneration.

Catalyst—Synthetic beads of co-precipitated chromia and alumina. Catalyst—manufactured by Socony Mobil Oil Co., Inc., near Paulsboro, N. J.—can be used with high sulfur crudes.

Regeneration—Carbon is burned from spent catalyst leaving the reforming reactor in a multi-zone type Thermofor kiln in several stages—with cooling in between—at 800-1000°F. Burning is controlled by the combustion air temperature. Kiln cooling coils generate steam. A kiln for a 15,000 b/sd TCR unit would be designed to burn 2000 lb./hr. coke with a catalyst throughput of about 25 tons/hr. Laboratory and pilot plants indicate that catalyst activity drops gasoline yield only 3% in equilibrating through repeated reforming-regeneration cycles.

Feed Stocks for Gasoline—Straight-run naphthas and cracked stocks or blends with high sulfur contents may be processed with most efficient yields from feed stocks in the 175-400°F. range.

Feed Stocks for Aromatics—Usually tailored to a narrow cut for optimum aromatics production.

Feed Stock Preparation—Though no mention is made of feed preparation, pilot plant studies showed that the presence of moisture in the reaction zone had an adverse effect on product yields. Therefore the recycle gas stream is dried before entering the reactor as shown on the flow diagram.

Process Operation—Referring to the flow diagram—reactor effluent is cooled and gas and liquid phases are separated in the primary separator, then recombined at a higher pressure before being reseparated in the recycle separator. Condensate from the recycle separator is stabilized to produce depropanized reformate which is then rerun to remove polymer. Gas from the recycle separator is split into two streams, the smaller of which has all C_3's+ and 90% of the C_4's absorbed by fresh naphtha feed in the absorber. The larger stream of recycle gas is heated and dried before joining the heated absorber effluent prior to entering the reactor. Catalyst is lifted to the reactor top by bucket elevators, enters the reactor and flows downward. Combined absorber naphtha and recycle gas feed enter the center of the reactor, flowing upward and downward to vapor disengaging sections, then recombining after leaving the reactor. Spent catalyst purges from the reactor base, then enters the regeneration kiln.

Operating Conditions—Operating temperatures range from 950°F. for easily reformed naphthas up to 1000°F. for refractory type stocks to give a F-1 + 3 cc TEL octane of 100. Pressures to 500 psig have been studied, but the desirable range is 100-200 psig. Lower pressures improve 10 lb. RVP gasoline yields and give increased hydrogen and coke. Gas recycle-to-naphtha ratios are best at 3-9 moles gas/mole naphtha. Increasing this ratio decreases coke "make" appreciably and increases the gasoline yield slightly while the recycle gas hydrogen content remains fairly constant. Space velocities are usually satisfactory at 0.7 volume of naphtha/unit volume of reactor. Catalyst-to-naphtha ratios have little effect on product yield or quality when varied over a wide range. In order to avoid thermal cracking in the naphtha heater, the outlet temperature should be limited to 900°F. maximum.

Product—Gasoline Operation—For some light feed stock, stabilized reformate can be used for gasoline blending with only a caustic wash. However, when naphthas of 400°F. end point—or higher—are charged, or when feed stocks have large amounts of cracked materials, the gasoline will have about 1% polymer which should be removed by a two stage rerun system as shown in the flow diagram or a polymer knockout drum immediately ahead of the final condenser. Also—as shown in Table 1—the pilot-plant gasolines have an olefin content requiring up to 3 lb./1000 bbl. of inhibitor. Table 1 presents pilot plant data for Thermofor Catalytic Reforming of crudes from various sources.

Thermofor — TCR

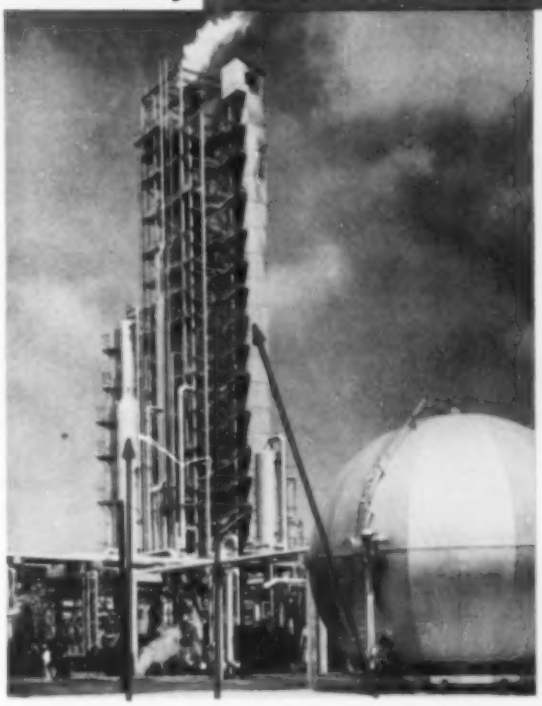
Table 1 — Thermofor Catalytic Reforming of Different Naphtha Types

Feed Stock Source	Colombia[1]	Mixed Texas[2]	West Texas[3]	Calif.[4]	Mixed and Virgin Cracked[5]
Gravity, °API	54.6	56.8	57.6	45.9	46.3
ASTM distillation, °F.					
IBP	177	128	166	166	225
10%	265	198	189	264	266
50%	298	268	212	338	314
90%	337	338	257	380	368
EP	380	384	295	401	400
F-1 clear octane	33.0	50.8	61.2	55.0	65.2
F-1 + 3cc TEL	60.6	68.4	75.2	71.5	75.4
Sulfur, wt.%	0.032	0.084	0.17	0.15	0.59
Norwood Bromine No.	0.9	3.0	1.7	1.0	36.7
Naphthenes, vol.%	—	—	—	63.0	—
Aromatics, vol.%	11.3	8.8	15.9	16.0	14.7
Olefins, vol.%	0.7	2.2	1.1	0.8	30.3
Paraffins, vol.%	—	—	—	20.0	—
Reformate					
Yields, charge basis					
C_4+, vol.%	83.0	86.6	89.7	82.7	87.9
C_3 (total), vol.%	8.6	7.9	4.6	4.8	3.6
C_4 (total), vol.%	8.4	7.5	3.9	6.5	4.7
C_2 and lighter, wt.%	16.1	12.1	8.6	14.5	10.0
Hydrogen, CF/bbl.	376	414	365	430	247
Coke, wt.%	0.7	0.3	0.2	1.5	1.4
C_4+ reformate					
Sulfur, wt.%	0.007	—	0.010	0.013	0.015
Norwood Bromine No.	9.5	9.8	8.2	17.4	13.5
Gravity, °API	53.2	55.4	55.4	44.4	46.6
Aromatics, vol.%	44.0	34.6	35.6	45.5	33.1
10 lb. RVP gasoline					
F-1 clear octane	91.1	87.0	85.4	94.9	89.3
F-1 + 3cc TEL	99.1	97.1	96.5	101.4	97.9
Vol.% of charge	82.0	87.2	96.1	85.4	94.0
Outside C_4's, vol.%	−1.0	0.6	6.4	2.7	6.1
Operating conditions					
Pressure, psig	175	175	175	175	175
Ave. reactor temp., °F	986	982	969	985	955
Space velocity, v/hr/v	0.88	0.72	0.70	0.50	0.80
Recycle gas-to-naphtha mole ratio	6.0	9.4	6.4	9.0	5.9
Recycle gas hydrogen, mole%	50	60	67	49	50
Recycle gas furnace outlet, °F.	1090	1070	1070	1050	987
Naphtha furnace outlet, °F	1030	1019	1013	1050	987

(1) Tibu-Petrolea paraffinic naphtha
(2) Mixed Texas naphthas
(3) Depentanrized West Texas naphtha
(4) Wilmington, California naphtha
(5) Blend of 54% straight-run naphtha and 46% coker naphtha from Wilmington crude.

Product—Aromatics Operation—Benzene, toluene and higher aromatics production at a reactor pressure of 100 psig are illustrated for various crude sources:

Feed Stock Source	West Texas	East Texas	Jackson	La Gloria	Seeligson
Light-medium naphtha					
Feed stock ASTM IBP, °F.	155	160	160	156	156
Feed stock ASTM EP, °F.	273	282	265	261	253
Aromatic yield, vol.% feed	32.9	27.0	32.1	31.2	30.3
Benzene	9.5	4.2	6.9	7.6	8.4
Toluene	17.9	15.0	18.7	16.3	15.7
C_8	5.5	7.8	6.5	7.3	6.2
Heavy Naphtha					
Feed stock, ASTM IBP, °F.	255	272	262	275	275
Feed stock, ASTM EP, °F.	330	358	356	349	402
Aromatic yield, vol.% feed	47.3	44.3	41.0	47.3	46.5
Benzene – Toluene	5.7	4.3	5.4	4.7	4.1
C_8	28.0	14.6	14.2	18.9	17.1
C_9 and heavier	13.6	25.4	21.4	23.7	25.3



STABILIZER REACTOR CATALYST ELEVATOR

THERMOFOR catalytic reformer at General Petroleum Corp., Torrance, Calif.—19,000 b/sd

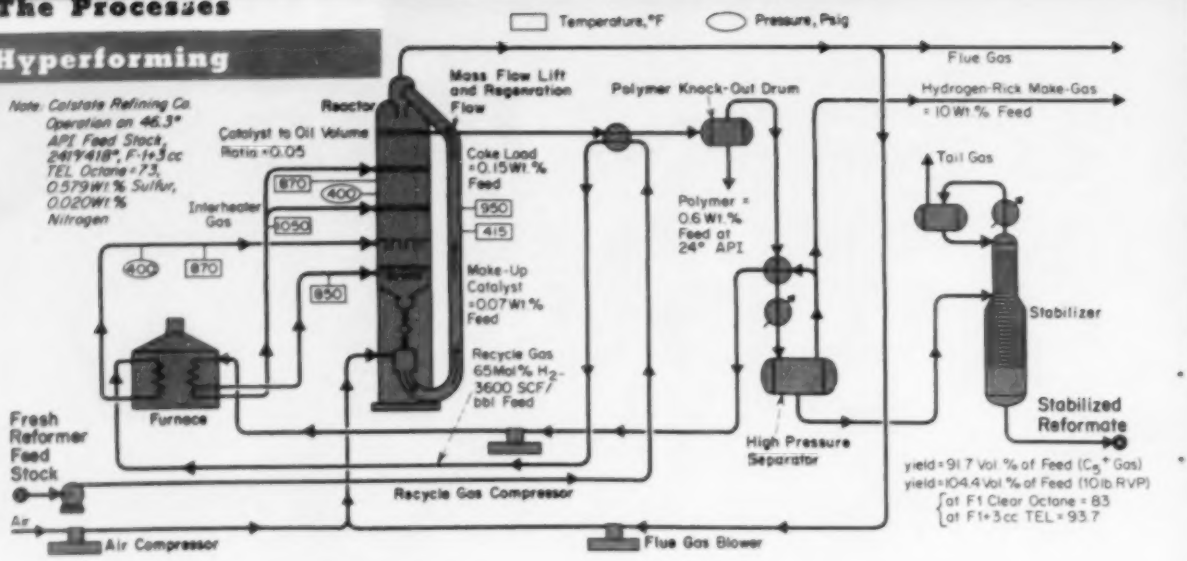
Equipment—The reactor for a 15,000 b/sd TCR unit is approximately 11 ft. in diameter. The naphtha furnace is designed for a high heat input rate to the tubes near the outlet in order to reduce time temperature effects. In units larger than 2000 b/sd, recycle gas will be circulated by a centrifugal compressor driven by a condensing turbine.

Economics—The only two TCR units to date are essentially prototypes which have been operating since March, 1955, therefore detailed investment cost is not available. However, a 1952 economics appraisal of a 3600 b/sd TCR unit in a 30,000 b/sd refinery processing Mid-Continent pipe-line crude estimated the TCR facilities to cost about $3,100,000—including the reformer, paid-up royalty and all off-site requirements. This TCR unit was designed to reform 260/410°F. boiling range virgin naphtha (41.4 F-1 clear, 64.2 F-1 + 3 cc TEL) to give 98 F-1 + 3 cc TEL octane reformate. Operating costs are:

	$/day
Labor and burden	260
Maintenance and shops	460
Fuel (includes steam and water)	466
Power	71
Chemical and catalyst	56
Laboratory	15
Supplies and misc	5
Taxes and insurance	78
Total operating cost per day	$1411
Operating cost per barrel feed stock	39.2¢

Installations—Two Thermofor Catalytic Reformers with capacities of 19,000 b/sd are operating. For a detailed tabulation of installations, see pp. 1166-69.

Licensor—Socony Mobil Oil Co., Inc., New York City.


Temperature, °F
Pressure, Psig
Note: Calstate Refining Co. Operation on 46.3° API Feed Stock, 241/418°, F-1+3 cc TEL Octane = 73, 0.579 Wt.% Sulfur, 0.020 Wt.% Nitrogen
Reactor
Catalyst to Oil Volume Ratio = 0.05
Mass Flow Lift and Regeneration Flow
Polymer Knock-Out Drum
Flue Gas
Hydrogen-Rich Make-Gas = 10 Wt.% Feed
Tail Gas
Coke Load = 0.15 Wt.% Feed
Interheater Gas
870
400
1050
950
415
Polymer = 0.6 Wt.% Feed at 24° API
Make-Up Catalyst = 0.07 Wt.% Feed
Stabilizer
Recycle Gas 65 Mol% H_2 - 3600 SCF/bbl Feed
Furnace
Stabilized Reformate
Fresh Reformer Feed Stock
High Pressure Separator
yield = 91.7 Vol.% of Feed (C_5^+ Gas)
yield = 104.4 Vol.% of Feed (10 lb RVP)
at F1 Clear Octane = 83
at F1+3 cc TEL = 93.7
Recycle Gas Compressor
Air
Air Compressor
Flue Gas Blower

Hyperforming

Process Type—Catalytic reforming of petroleum naphthas with cobalt-molybdate catalyst through a single moving-catalyst-bed reactor with continuous catalyst regeneration.

Catalyst—Tablets (3/16-in. diameter and 3/16-in. long) made of cobalt molybdate with a silica-stabilized alumina base. Sulfur, nitrogen and other materials found in inferior crudes do not poison the catalyst. The catalyst is made by the Harshaw Chemical Co.

Regeneration—Carried out simultaneously with the vertical "mass conveyance" of catalyst from the bottom to the top of the reactor by burning carbon from the catalyst using a recycle of flue gas containing less than 2% oxygen—allowing precise control and moderate regeneration temperatures.

Feed Stocks For Gasoline—Straight-run naphthas and cracked stocks or blends with high sulfur and nitrogen contents and boiling between 150 and 450°F. may be processed.

Feed Stocks For Aromatics—There is no published data on Hyperforming for aromatics, but the generalization that optimum aromatics production is obtained from tailored narrow cuts would appear to apply.

Feed Stock Preparation—Due to the controlled hydrocracking in Hyperforming—allowable due to continuous catalyst regeneration—high end-point feeds may be reformed without precise prefractionation. The character of the catalyst and catalyst regeneration allows reforming of high-sulfur, high-nitrogen crudes without pretreatment.

Process Operation—Referring to flow diagram—catalyst moves downward through the reactor with gravity flow and is returned to the top of the reactor by means of mass conveyance in a catalyst transfer line—similar to the mass conveyance system used many years in the Hypersorption process. Catalyst is regenerated in the lift line during elevation to the top of the reactor. Catalyst enters the lift system through a lock system at the base of the reactor. Elutriation of catalyst fines is at the flue gas disengaging point at the top of the lift line and catalyst dust is removed in a small cyclone separator. Feed naphtha enters the reactor bottom, and naphtha vapor, together with recycle gas, flows upward counter-current to the descending catalyst. Interheating at several points in the reactor is accomplished by injection of hot hydrogen recycle gas. Reaction products exit near the reactor top. Reformate is cooled, then passes through a polymer knockout drum, after which recycle the reaction products are cooled, then separated into hydrogen-rich gas and unstablized reformate. After stabilization the reformate is ready for gasoline blending.

Operating Conditions—A reactor pressure of 400 psig is recommended as optimum for minimum coke laydown in relation to other process variables. The use of heated recycle gas to interheat the reactor means that reactor temperature control does not involve other process variables. Reactor temperatures are in the range of 800-900°F. (maintained around 900°F. for straight-run feed stock). Hydrogen recycle is on the order of 3000 SCF/bbl. feed stock. Catalyst circulation is low—on the order of 5 tons/hr. for 10,000 b/sd Hyperformer charging straight-run feed. Other typical operating conditions—for the 1100 b/sd Calstate Refining Co. Hyperformer—are on the flow diagram.

Product—Gasoline Operation—By using outside hydrogen, or blending with straight-run naphthas, cracked stocks with as much as 3½% sulfur have been refined. In addition, Hyperforming eliminates nitrogen and oxygen compounds in inferior feed stocks. Table 1 illustrates reforming of different feed stock types, indicating that paraffin cyclization produces as high as 161% more aromatics than can be accounted for by feed naphthene dehydrogenation. Up to 30% paraffins have hydrocyclized in feed stocks with as low as 11% naphthenes. Controlled selective hydrocracking of high molecular weight paraffins produces light gasoline from heavy stocks as shown for Santa Maria crude in Table 1 where Hyperforming produces a 60°F. drop in mid-point boiling range—while upgrading 80 octane feed stock to 94.5 F-1 + 3 ml TEL octane and decreasing sulfur by 95% and nitrogen by 90%.

Product—Aromatics Operation—As mentioned previously, there is no information on Hyperforming specifically for aromatics. However Table 1 indicates appreciable dehydrocyclization of paraffins.

Economics—Plant charge capacity is a major variable determining construction costs. To a lesser degree, feed stock sulfur content affects costs by determining alloy requirements. Investment costs are estimated at $150-$300 per barrel feed capacity with initial catalyst investments of $20 per b/sd capacity. Table 2 gives Calstate Refining Co.'s, Signal Hill, Calif., utility and catalyst requirements, while Table 3 gives estimated operating costs.

Equipment—The 1100 b/sd Calstate Refining Co. Hyperformer reactor is 30 ft. long and 4.5 ft. in diameter. Reactor internals include a number of feed-engaging and disengaging trays with downward spouts to conduct solids downward uniformly. Vapor engaging or disengaging occurs underneath the trays. The reactor is of low chrome-moly steel. All other vessels are carbon steel. High-temperature furnace tubes and transfer lines are alloy.

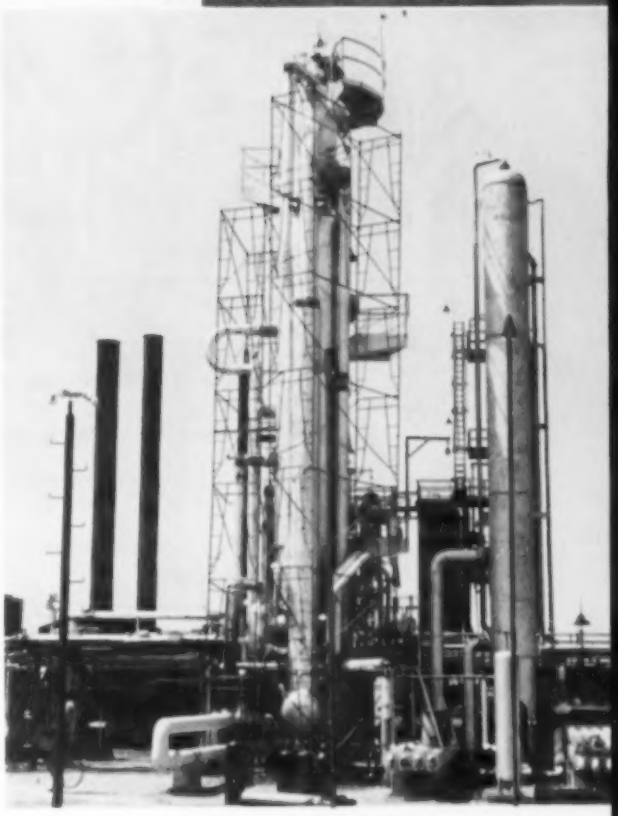
Installations—One Hyperformer is in operation at Calstate Refining Co., Signal Hill, Calif., with a 1100 b/sd capacity.

Licensor—Union Oil Company of California, Patent Division, Research Department, Brea, Calif.

Table 1 — Hyperforming of Different Naphtha Types

Feed Stock Source	Mid-Continent	Coker Distillate*	Straight-run cracked blend**
Gravity, °API	51.8	52.7	46.3
Engler Distillation, °F			
Initial	256	147	241
10%	270	192	270
30%	280	—	—
50%	292	267	316
70%	311	—	—
90%	340	342	381
Maximum	382	390	418
F-1 clear octane	40	—	61.8
F-1 + 3cc TEL	63	80	73.0
Sulfur, wt.%	0.05	3.47	0.579
Nitrogen, wt.%	0.01	0.020	0.020
Naphthenes, vol.%	27	—	—
Aromatics, vol.%	19	—	—
Paraffins, vol.%	53	—	—
Olefins, vol.%	1	—	—
Reformate			
Reforming severity	Low	High	—	—	—
Yields, charge basis					104.4[1]
C_5+, vol.%	93.9	88.4	—	91.3	91.7[1]
Butanes, vol.%	4.6	8.3	—	—	3.7
Dry gas, SCF/bbl.	300	423	—	—	564
Reformate	C_5+	C_5+	not given	C_5+	10 lb. RVP
Engler dist., °F					
Initial	—	—	87	—	97
10%	209	158	131	—	168
50%	280	270	205	—	280
90%	335	349	328	—	380
Maximum	—	—	429	—	427
Sulfur, wt.%	—	—	0.035	—	0.007
Nitrogen, wt.%	—	—	0.002	—	—
F-1 clear octane	84.2	96.1	—	91.5	83.0
F-1 + 3cc TEL	94.9	101.7	94.5	98.9	93.7
Gravity, °API	52.2	52.8	60.0	—	52.8

(1) C_5+ reformate
(2) 10 lb. RVP with addition of 9% outside butanes to C_5+ reformate
* Santa Maria light coker distillate
** Cracked and straight-run blend from Los Angeles basin crude



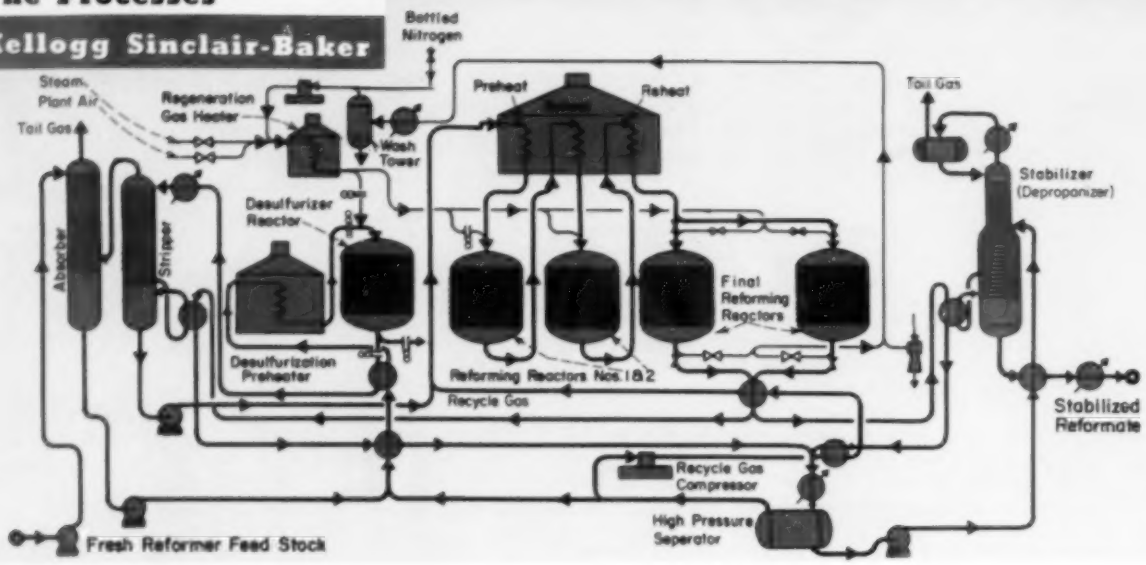
HYPERFORMER at Calstate Refining Co., Signal Hill, Calif. —1100 b/sd

Table 2—1100 b/sd Hyperformer Utilities and Catalyst Requirements

Fuel Gas (thousands of Btu/hr)	
Produced by unit (710 Btu/SCF)	18,400
Required by unit for fired heaters	11,350
Net production from unit	7,050
Instrument air, SCF/min.	45
Cooling water (38°F. rise), gpm.	263
Electrical Power, kw:	
Lighting and instruments	25
Pumps and compressors	92
Total electric power	117
Catalyst makeup, lb./sd	9

Table 3—1100 b/sd Hyperformer Estimated Operating Cost

Utilities	¢/bbl. feed
Fuel gas @ 16¢/million Btu	4.0
Power @ 0.7¢/kwh	2.6
Water @ 0.078¢/cu. ft.	0.4
Catalyst @ $1.30/lb.	1.0
(Process guarantees on the order of 3¢/bbl. can be obtained.)	
Labor	6.0
Operating supplies	0.2
Maintenance and general overhead	3.5
Credit for fuel gas produced @ 16¢/million Btu	6.7
Net operating cost (exclusive of royalty)	11.0



Kellogg Sinclair-Baker

Process Type—Catalytic reforming of naphthas with Sinclair-Baker "RD-150" platinum-containing, regenerable catalyst through a series of fixed-catalyst-bed reactors.

Catalyst—Sinclair-Baker RD-150 catalyst.

Regeneration—In situ regeneration possible. Either the third or fourth reactor may be shut down for regeneration without materially disturbing operations.

Feed Stocks for Gasoline—Light, heavy and full boiling range naphthas have been reformed successfully.

Feed Stock Preparation—It is usually economically desirable to use a high-pressure cobalt-molybdena reactor–to desulfurize, saturate olefinic compounds and remove harmful metallic, nitrogen and arsenic compounds–ahead of the reforming reactors.

Process Operation—Referring to the flow diagram–four fixed-bed reactors are used, the final two in parallel operation. After desulfurization, naphtha and recycle gas are combined and heated to reaction temperature, then sent through the reforming reactors and interheaters. Final reactor effluent is cooled and separated into a liquid. The liquid product is stabilized to make gasoline product.

Operating Conditions—The preferred range of reactor conditions is 300-500 psig and 900° F. maximum–to minimize thermal reactions–with a recycle gas rate of 4000-6000 SCF/bbl. feed.

Product—Gasoline Operation—The data below gives typical yields for reforming an East Texas virgin heavy naphtha–250-390°F. boiling range 50 F-1 clear octane.

F-1 clear octane (C_5+)	85	90	95
Yield, C_5+ reformate, vol.%	91.0	88.2	84.7
Yield, C_4's, vol.%	2.2	3.0	4.0
Yield, dry gas, wt.%	4.7	6.0	7.7

Data for reforming Middle East paraffinic virgin heavy naphtha is:

Feed Stock		
Gravity, °API	52.8	
ASTM distillation, °F.		
IBP	250	
10%	293	
50%	323	
90%	360	
EP	385	
F-1 clear octane	25.9	
F-1 + 3cc TEL	51.1	
Reformate	**Case A**	**Case B**
Yield C_5+ reformate, vol.%	78.5	80.8
Yield C_4's, vol.%	6.4	5.8
Yield dry gas, wt.%	10.5	9.2
F-1 clear octane (C_5+)	95	95
Operating Conditions		
Pressure	high	low
Reactor temperature, °F.	900	900
Recycle gas rate, SCF/bbl.	5000	5000

Economics—Installation costs are $125-300 per barrel for capacities from 3000 to 30,000 b/sd. Typical operating costs are given below for a 10,000 b/sd unit.

Feed Stock Source	Kuwait		Mid-Continent	
Product Octane–F-1 clear of C_5+	90	95	90	95
Operating cost, ¢/bbl. feed				
Fuel @ $0.90/bbl.	5.2	5.2	5.2	5.2
Power @ $0.007/kwh.	2.0	2.3	2.0	2.0
Water @ $0.007/thousand gal.	0.5	0.6	0.5	0.5
Catalyst (reforming)	6.8	10.8	4.0	6.7
Catalyst (desulfurizing)	0.5	0.5	0.5	0.5
Labor @ $55/day	1.4	1.7	1.4	1.4
Supervision @ 15% labor	0.2	0.2	0.2	0.2
Total direct operating cost	16.6	21.3	13.8	16.5
Maintenance @ 4% process equip. invest.	2.2	2.5	2.2	2.3
Property taxes and insurance @ 2% process investment	1.5	1.8	1.4	1.6
Interest @ 4% total process invest.	3.0	3.6	2.8	3.2
Depreciation @ 10% process equip. invest.	5.5	6.2	5.5	5.7
Total Operating cost, ¢/bbl. feed	28.8	35.4	25.7	29.3

Installations—One 3000 b/sd Kellogg-built platinum reforming unit is operating at Pure Oil Co, Heath, Ohio.

Contractor—M. W. Kellogg Co., 225 Broadway, N. Y. C.

How to Recover the Aromatics

THE aromatics content of refinery streams may range from 10% in straight-run stocks to around 50-60% in catalytic reformate. However, since petroleum distillates are a mixture of many hydrocarbon types, the resulting azeotrope formation makes it virtually impossible to recover pure aromatics by distillation alone.

An early approach to the separation of aromatics from petroleum streams was based on the greater thermal stability of aromatics as compared to paraffins or naphthenes. This allowed the "cracking" of an aromatic rich stream to remove non-aromatics as light ends.

Modern examples of "cracking" to recover aromatics include the Catarole process, still used in England, and the two-pass Hydroforming process used by Standard Oil Co. (Calif.) for World War II toluene.

Another approach used during World War II—at the Baytown Ordnance Works, Baytown, Texas, to produce xylenes – took advantage of the increase in boiling point resulting when a naphthene is converted to an aromatic during catalytic reforming. For example, when methylcyclohexane is converted to toluene, the boiling point increases from 213 to 231°F.

For aromatics today, it is generally most economical to handle mixed hydrocarbon streams. The commercial aromatics recovery processes–described on pp. 1198-1202–utilize some modification of phase relationships to create circumstances selective to the separation of the desired material. These processes may be classed as (1) vapor-liquid, (2) liquid-liquid, and (3) liquid-solid.

The two commercial vapor-liquid processes for aromatics recovery are extractive distillation–described on page 1198–and azeotropic distillation, used in two installations during World War II, but not used widely today.

Addition of a polar agent, such as alcohols, ketones, phenols, etc. to an aromatic hydrocarbon mixture can greatly increase the volatilities of paraffins, naphthenes, or olefins relative to aromatics.

In extractive distillation the added agent is a solvent for aromatics which allows non-aromatic hydrocarbons to be rejected in the distillation tower overhead, while aromatics plus solvent leave as tower bottoms to be separated later.

Azeotropic distillation differs from extractive in that the solvent for the aromatics–which can be methanol or methylethylketone – is called an "entrainer" and carries the aromatics overhead in an aromatic-solvent azeotrope which must later be broken.

Liquid-liquid recovery processes provide a second liquid phase which is selective for some desired component in the feed stock.

Udex and Modified SO_2 Extraction are the liquid-liquid processes in commercial use for aromatics recovery – described on pages 1199 and 1200, respectively.

These processes have an advantage over vapor-liquid processes in that the liquid-liquid systems can simultaneously recover benzene, toluene, mixed xylenes and other aromatics whereas the distillation methods can recover only one aromatic at a time and require blocked-out operation or duplicate separation facilities for a second aromatic.

The liquid-solid processes, Arosorb and Cyclic Adsorption–described on pages 1201 and 1202, respectively–are both based on silica gel's selective adsorption properties for aromatics.

Instead of costly regeneration of the gel by heating to expunge the adsorbed aromatics as is practiced in the laboratory, both processes use hydrocarbon "desorbent" streams to recover the aromatics from the silica gel and prepare the gel for another adsorption cycle.

Finishing operations, consisting of a sulfuric acid treat, caustic wash, rerun, etc., are generally needed to meet the ASTM nitration-grade acid wash color specifications.

	Benzene	Toluene	Xylene
Specific gravity	0.8820-0.8860	0.8690-0.8730	0.8650-0.8700
Color	water white	water white	water white
Br. index, mg br/100 gm....	—(a)	—(a)	—(a)
Acid Wash Color:			
Acid phase	2 max.	2 max.	6 max.
Hydrocarbon phase	0	0	0
Solidifying pt., anhyd., °C	4.85 min.	—	—
Acidity, mg NaOH/100 ml.	no free acid	no free acid	no free acid
Copper corrosion ..	—(b)	—(b)	—(b)
H_2S and SO_2	none	none	none
100 ml. distillation range, °C	1 max. (c)	1 max. (d)	3 max. (e)
Paraffin, %-vol. ...	—	1.5 max.	4.0 max.

(a) Proposed ASTM method, max. probably in range 25-50 Bromine Index.
(b) Strip shall not show irridescence, or gray or black deposit or discoloration.
(c) Including the temperature 80.1°C.
(d) Including the temperature 110.6°C.
(e) Including the temp. 139.3°C. Initial b.p. not below 137.2°C. and dry pt. not more than 140.5°C.

While aromatics from virgin stocks need little treatment, if any, aromatics from cracked stocks may require treats of up to 20-30 lb. sulfuric acid per pound of aromatic.

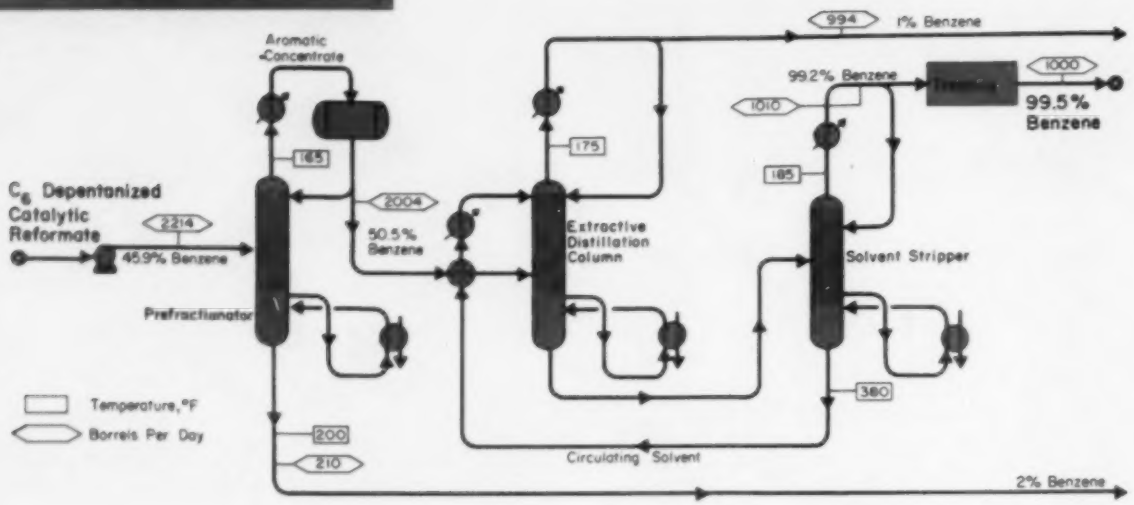
Increasing interest in para- and ortho-xylenes for synthetics and other petrochemical products has led to the development of commercial processes for the separation of xylene isomers.

Ortho-xylene – a naphthene substitute which gives phthalic anhydride upon oxidation – can be obtained from mixed xylenes by super fractionation.

Para-xylene–used for terephthalic acid in Dacron manufacture–has a freezing point over 100°F. higher than other xylene isomers, so can be recovered by crystallization.

No large scale uses have developed for the other two xylene isomers – meta-xylene and ethylbenzene.

The recovery of other aromatics in the C_9 and C_{10} range formed during catalytic reforming is still in the laboratory stage, but probably could be developed commercially as large scale uses developed.



Extractive Distillation

Process Type—Continuous recovery of individual aromatics by distillation using a solvent to increase vapor pressure differences between components.

Feed Stocks—Can be straight-run, cracked or reformed naphthas or gasolines or dehydrogenated naphthenes.

Feed Stock Preparation—Requires partial olefin removal from thermally reformed and cracked fractions—by sulfuric acid or clay pretreat—and from true vapor-phase cracked gasoline—by phosphoric acid.

Feed prefractionation is needed to give a concentrate fraction with a single aromatic. If bulk of higher-boiling non-aromatics are removed, the remaining close-boiling paraffins, naphthenes, olefins and cyclo-olefins go to the overhead raffinate in the extraction step.

Process Operation—(1) prefractionation of feed, (2) distillation of fraction in presence of higher boiling solvent such as phenol, followed by stripping the aromatic from the solvent, and (3) treating, to pass nitration-grade aromatics acid-wash color test.

Referring to flow diagram—for plant recovering benzene from depentanized catalytic reformate—feed is charged to prefractionator (usually 65 trays). Aromatic concentrate enters the extractive distillation column (60-70 trays) about one-third from the bottom and lean solvent enters about two-thirds from the bottom. Solvent is knocked back in the upper section by overhead hydrocarbon reflux. Top product is essentially free of aromatics and solvent. Aromatic-solvent mixture from extractive distillation column bottom is separated in the stripping column (30 trays). A single-stage solvent cleanup still continuously removes high-boiling phenol-diolefin reaction products and iron. Phenol reaction products are less than 1 bbl./week in a plant recovering 1000 b/d benzene from hydrogenation product.

Separate distillation columns are recommended for each nitration-grade aromatic, though blocked-out operation for alternate production of all types is possible. Phenol is usually used for benzene or toluene recovery, and mixed cresylic acids for xylene recovery.

Equipment—In phenol service is carbon steel except valve trim, reboiler tubes and tube sheets in extractive distillation and stripping columns which are 316 stainless. Hot solvent pumps are special Fe-Cr-Ni alloy.

Aromatic Products—Can meet specifications for nitration-grade benzene or toluene with purities of 99.0%—having less than 0.1% of a second aromatic—and yields of 97-99%. The flow diagram gives material balances for a benzene recovery unit.

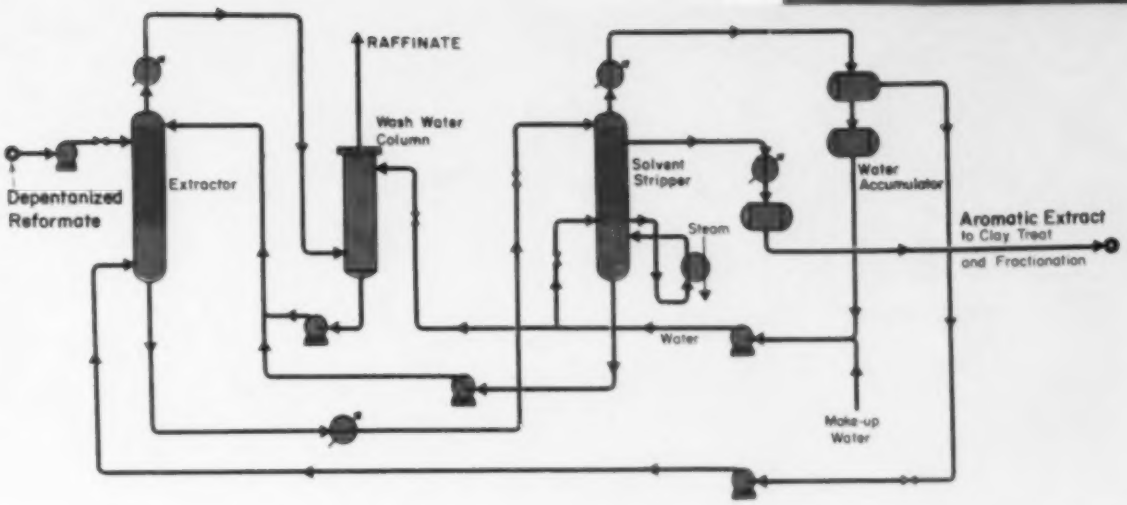
Economics — Quantities of chemicals and utilities, and cost of labor — per barrel of recovered benzene — for the process as shown in the diagram are:

Chemicals	
Phenol, lb.	0.2
98% sulfuric acid, lb.	3.0
Caustic, lb.	less than 1
Utilities	
Fuel, millions of Btu's.	1.1
Cooling water (90 to 120°F.), gal.	3100
Electric power, kwh	3.3
Operating labor (direct cost), cents	14
Maintenance labor and materials, cents	10

Installations—Commercial units recovering aromatics by extractive distillation are:

Atlas Processing Co.	Shreveport, La.
Continental Oil Co.	Penca City, Okla.
Pan American Refining Corp.	Texas City, Texas
The Pure Oil Co.	Toledo, Ohio
Shell Oil Co.	Houston, Texas
Shell Oil Co.	Wilmington, Calif.
Shell Oil Co.	Wood River, Ill.
Standard Oil Co. (Calif.)	El Segundo, Calif.
Standard Oil Co. (Ind.)	Whiting, Ind.

Licensor—Shell Development Co., Emeryville, Calif.



Udex

Process Type—Selective extraction of aromatics from various feed stocks by absorption in an aqueous diethylene glycol solution.

Feed Stocks—Aromatics may be separated from wide-boiling feed stocks.

Feed Stock Preparation—If nitration-grade aromatics are desired, a high conjugated diene content requires selective prehydrogenation of the feed. If alkenyl-aromatics are high in the feed, the extraction must be preceded or followed by selective hydrogenation.

Process Operation—Aqueous diethylene glycol solvent exhibits a selectivity roughly proportional to the carbon hydrogen ratios of the feed components and inversely proportional to their boiling points. Solvent selectivity and solubility changes slowly with temperature, but can be varied as required for different feed stocks by changing the water content–which is usually 8-10%. Adjustment of the solvent/hydrocarbon feed ratio allows control of extraction efficiency, with higher boiling aromatic fractions requiring a greater proportion of solvent.

Referring to the flow diagram–hydrocarbon feed rises in the extractor, having specially designed trays, and comes into countercurrent contact with the descending solvent–diethylene glycol-water solution. The solvent extracts aromatics from the feed. Paraffinic hydrocarbons leave the extractor top as raffinate, while the rich solvent from the tower bottom goes to a stripper which separates aromatics as the net product. Stripped solvent returns to the extractor tower, completing its cycle.

Stripper vapors are condensed and separated as a water phase–returned to the system–and a hydrocarbon phase which is clay treated and separated into individual aromatics by distillation.

Equipment—Pressures, which are just high enough to maintain liquid phase conditions, low temperatures and solvent characteristics are such that low pressure carbon steel equipment may be used.

Aromatic Products—Udex extraction recovers nitration-grade aromatics–after acid and clay treat–with 99+% purities and high yields as shown in Table 1.

Economics—Udex operating data for the 1650 b/sd charge capacity unit at Cosden Petroleum Corp.'s Big Spring, Texas, refinery–recovering approximately 120 b/sd benzene, 350 b/sd toluene, and 330 b/sd xylenes from catalytic reformate–is shown in Table 2.

Installations—Seven Udex extraction units are in commercial operation with charge capacities of 500-7200 b/sd. Others are in design or construction stages. (See pp. 1166-9)

Licensor—Universal Oil Products, 30 Algonquin Road, Des Plains, Ill.

Table 1 — Typical Aromatic Recoveries

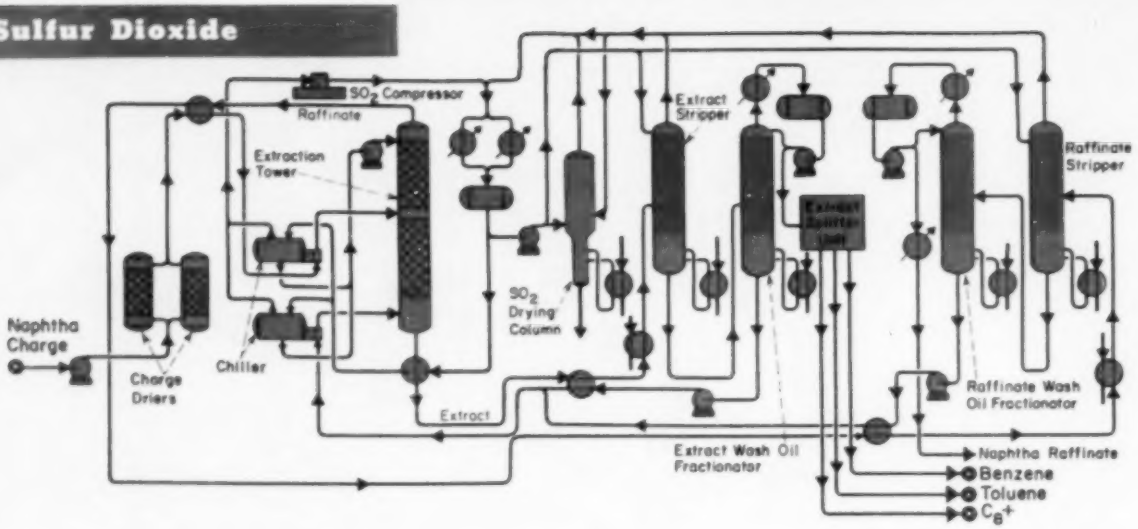
Stream or component	Vol. % of Extract	Vol. % of feed	Vol. % of recovery in extract
Benzene	15.3	7.6	99+
Xylenes & ethyl benzene	40.4	20.0	94
Toluene	42.5	21.2	98
C_9+ aromatics	1.8	0.9	75
Total extract	100.0	49.7	

Table 2 — Utilities, Labor and Chemicals

1650 b/sd Udex at Cosden Petroleum Corp.

Utilities	per bbl. product
Steam, 150 psig	775
Udex	520
BTX fractionation	255
Power, kw	0.59
Cooling water, gal. circulated	1420
Chemicals	
Diethylene glycol[1], lb.	0.05
Clay,[2], lb., (8000 bbl. aromatics/ton clay life)	0.24
Maintenance material and labor, $	0.10
Operating labor, 1½ men/shift, $	0.10

[1] About 22,000 gal. used to fill system
[2] Clay cost around $35/ton



Modified SO_2 Extraction

Process Type — Selective extraction of aromatics from catalytic reformate by scrubbing with liquid sulfur dioxide – a modification of the process suggested by Edeleanu in 1907 for the removal of aromatics from kerosine by SO_2 extraction.

Feed Stocks — The process described is primarily for recovering aromatics from catalytic reformate–ranging from benzene to C_{10} aromatics – but minor modifications permit blocked-in operation for a wide variety of charge stocks including kerosines, diesel fuels, gas oils and furnace oils.

Feed Stock Preparation — Reformer feed stock is inhibited with 1 - 2 lb/1000 bbl. of 2,6-ditertiary butylparacresol as it leaves reformer to prevent formation of resin contaminants in storage or under the low temperatures in the extraction section. Sulfur dioxide is very corrosive when wet, therefore water content in the reformate feed stock is reduced to 30ppm – with alumina driers.

Process Operation — Referring to the flow diagram – naphtha charge is pumped through alumina drier to remove water, then cooled by heat exchange with raffinate solution and chilled by refrigeration with SO_2. Chilled naphtha is then introduced at an intermediate point in the Raschig ring packed extraction tower. The charge is stripped of aromatics by counter-current scrubbing with liquid SO_2 at –20°F. Raffinate solution – essentially free of aromatics – leaves the tower top. The high gravity, aromatics enriched SO_2 phase flows downward through the tower and is, in turn, countercurrently contacted with wash oil – a kerosine fraction partially soluble in the SO_2. As the kerosine goes into solution, it displaces lower boiling non-aromatics which then flow up through the tower and become part of the raffinate solution. Extract solution – from the base of the extraction tower – contains aromatics, wash oil and SO_2.

Extract and raffinate solutions are sent to their respective fractionation sections in which the SO_2 and wash oil are recovered in separate steps. The recovered solvent and wash oil streams are recycled to the extraction tower.

The aromatic fraction can then be split, by fractionation, into benzene, toluene, and mixed xylenes product streams.

Equipment — Intermediate storage tanks between the reformer and extraction unit have floating roofs to minimize resin formation resulting from reactions with oxygen. Type 316 stainless is used in SO_2 and wash oil recovery systems.

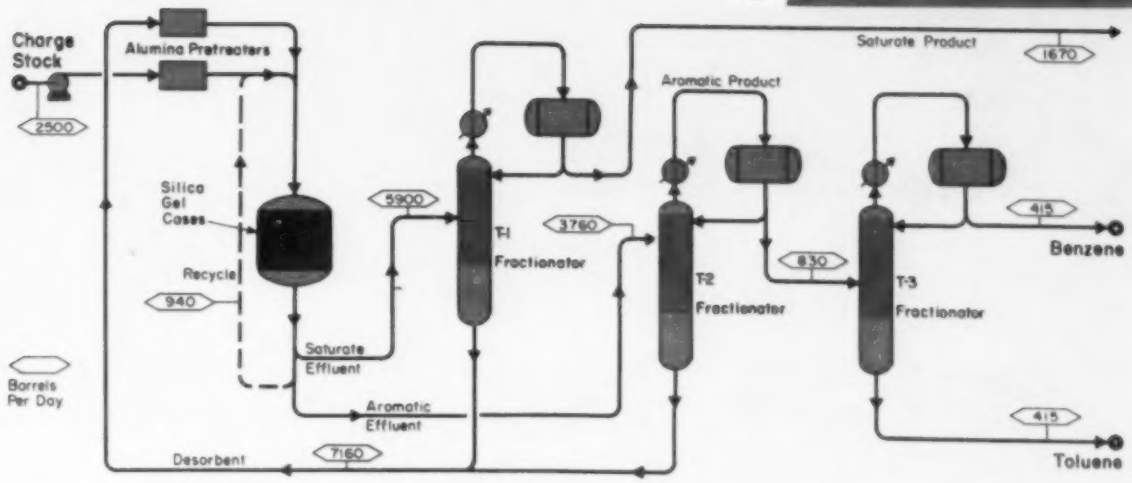
Aromatic Products — Recoveries of individual aromatics are 98-99% with product purities of 99 + %, nitration-grade requirements for benzene and toluene are met after acid-treat and clay-treat.

Economics — The process consumes liquid sulfur dioxide at the rate of about 0.15 lb/bbl. charge. Investment and direct operating costs for a plant of 4000 b/sd naphtha charge are given below:

Plant Design		
Charge capacity, b/sd naphtha		4000
Vol. % SO_2, charge basis		170
Vol. % wash oil, charge basis		75
Temperature, °F.		
Plant cost – including hot gas oil heater		$2,500,000
Direct operating cost, ¢/bbl. charge		22.1
Utilities – ¢/bbl.		9.3
Fuel @ 10¢/million Btu	3.3	
Cooling water @ 1¢/thousand gal.	1.6	
Power @ 1¢/kwh	1.6	
Steam @ 25¢/thousand lb.	2.8	
Chemicals – ¢/bbl.		3.6
Sulfur dioxide	2.0	
Caustic	1.6	
Labor, ¢/bbl.		3.7
Maintenance at 3%, ¢/bbl.		5.5
Royalty		None

Installations — Three installations reported. The Baytown Ordnance Works unit at Baytown, Texas – now owned by Humble Oil and Refining Co. – was built during World War II to recover pure aromatics. The Continental Oil Co. unit at Lakes Charles, La., with a charge capacity of 3570 b/sd, was installed in 1953 by Stone and Webster for the separation of benzene and mixed toluene-xylenes from catalytic reformate. Tide Water Associated Oil Co. has a 1100 b/sd unit at Avon, Calif., for aviation blending stocks.

Contractor — Process available from the Badger Process Div. of Stone and Webster Engrg. Corp., Boston, Mass.



Arosorb

Process Type — Separation of aromatics from petroleum hydrocarbons by a cyclic selective adsorption-desorption process in fixed silica gel beds.

Feed Stocks—Almost any available refinery stream boiling 150-700°F. and having either large or small proportions of aromatics, such as catalytic reformate, kerosine, etc.

Feed Stock Preparation—Consists of passing feed stock over fixed-bed activated alumina driers to reduce feed stock water content to a level of 20 ppm; remove silica gel poisons such as trace quantities of nitrogen, sulfur and oxygen compounds; and reduce amounts of organic polar compounds and readily polymerizable olefins.

Process Operation—The Arosorber can be used for the separation of olefin, non-hydrocarbon organic, and other liquid materials.

There are two basic types of Arosorb operations, (1) for low-boiling feed stocks, the gel desorbent boils higher than the charge, and (2) for high-boiling feed stocks, a lower-boiling desorbent is used. The first is typical of recovery from reformate, the second, of kerosine treating.

Referring to the flow diagram–for a plant recovering benzene and toluene from catalytic reformate–pretreated feed stock passes into one of several gel cases for 30 minutes, then is diverted to a second gel case. The first gel case is then fed with the desorbent–crude xylene stream with about 65% xylenes–which pushes the saturates out of the silica-gel bed and then displaces adsorbed aromatics.

The first gel-case effluent contains the "pushed out" saturates which go to tower T-1 to recover saturate as overhead and desorbent as bottoms. The intermediate portion of the gel-case effluent–containing a mixture of feed stock staturates and desorbing aromatics can be recycled to mix with fresh charge stock, if high-purity products are desired. The final portion of the gel-case effluent–containing desorbed aromatics–is fractionated in tower T-2 to give an aromatic overhead and a desorbent bottom. Fractionator T-3 does the final benzene-toluene splitting.

Equipment—Commercial silica gel made by the Davison Chemical Co.–granular particles 28-200 mesh–is placed in one or more gel-bed cases with diameters of 3 to 10 ft. and heights of 15 to 30 ft. Carbon steel is used for gel-bed cases. A life of over one-year is estimated for silica gel.

Aromatic Product—Nitration-grade benzene and toluene –after a light acid treatment–may be separated from catalytic reformate with purities of 99% and high yields.

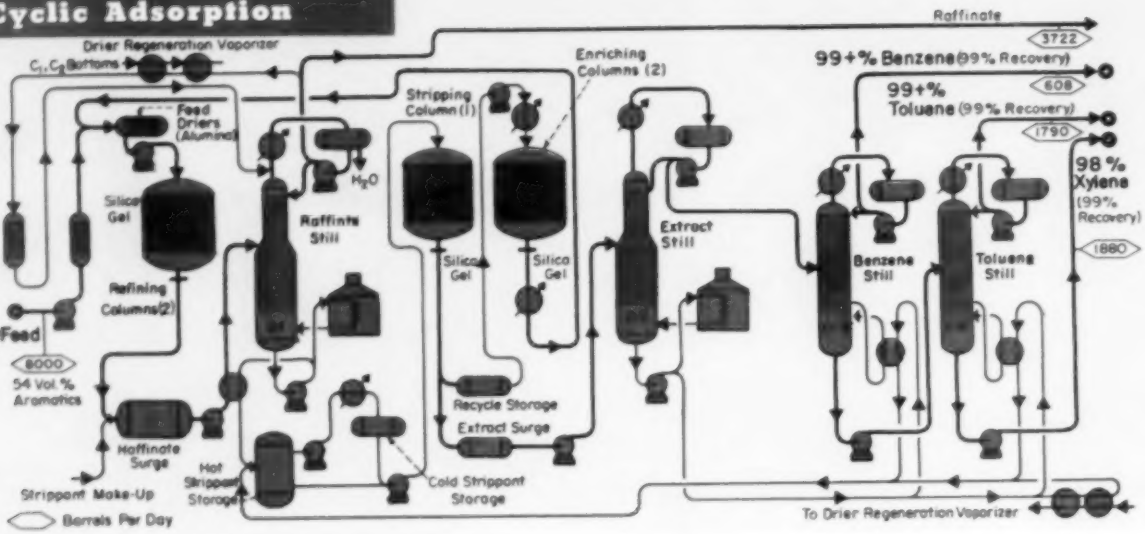
Economics—Investment and operating costs–not including the small running or paid-up royalty figure–to recover benzene and toluene from catalytic reformate are:

Arosorber capacity, b/sd feed	500	2500	5000
Investment,[1] millions of $	0.72	1.60	2.26
Fixed charges, $/day	306	679	960
Depreciation, 10 years	197	438	619
Insurance and taxes, 0.5%	10	22	31
Maintenance, 5%	99	219	310
Direct charges, $/day	198	503	886
Labor[2,3]	120	120	120
Utilities[2]			
Power @ $0.005/kwh	7	35	70
Fuel @ $0.12/million Btu	17	84	168
Steam @ $0.25/100 lb.	8	37	74
Water @ $0.02/100 gal.	9	44	88
Supplies			
Xylene	2	10	20
Silica gel	32	161	322
Activated alumina	3	12	24
Total operating cost	504	1182	1846
Dollars/bbl., feed	1.01	0.47	0.37
Cents/gal., feed	2.35	1.12	0.88

[1] Based on an erected plant within battery limits, including silica gel, activated alumina, and engineering and contractor's fees.
[2] Based on approximate Gulf Coast figures.
[3] Includes 2 men/shift @ $2.00/hr. plus supervision of 1 man for 1 shift/day @ $3.00/hr.

Installations—A 500 b/sd Arosorber operated by Petrocarbon Chemicals, Inc., Irving, Texas for aromatic solvents.

Licensors—Universal Oil Products Co., 30 Algonquin Road, Des Plains, Ill., and Houdry Process Corp., Philadelphia, Pa., authorized by Sun Oil Co. to license Arosorb.



Cyclic Adsorption

Process Type—Separation of aromatics from petroleum hydrocarbons by a cyclic selective adsorption-desorption process in fixed silica gel beds.

Feed Stocks—Cyclic Adsorption recovers aromatics from a wide range of feeds – catalytic reformate, kerosine, etc.

Feed Stock Preparation—Feed stocks should be reasonably free from water, which can be removed in alumina driers, and other polar compounds, such as sulfur, hydrogen, oxygen compounds, diolefins, etc. which may be removed in small guard chambers ahead of the main gel cases.

Process Operation – Primary interest is the recovery of C_6 to C_8 aromatics from catalytic reformate, but can be used to produce dearomatized kerosines or odorless paraffins for thinners and solvents, or recover relatively pure heavy aromatic hydrocarbons from lubricating oil stocks for use as chemical synthesis raw materials. Also olefins can be separated from cracked stocks.

Referring to the flow diagram – for a plant recovering benzene, toluene and xylenes from catalytic reformate – pretreated feed stock is passed through the first refining zone adsorption vessels in which the aromatics are adsorbed in the silica gel, and a paraffinic raffinate is produced. The raffinate which becomes mixed with strippant in the adsorption zone is separated from the strippant in the raffinate still. At the end of the refining period – about 30 minutes for catalytic reformate, and about 2 hrs. for kerosine–vessels of the second refining zone which contain adsorbed aromatics and feed paraffins are switched to the first enriching zone and then to the second enriching zone. During the enriching, feed paraffins are displaced by a recycle stream with enriching zone effluent returning to the feed to recover its aromatic content.

The enriching recycle is obtained as the first liquid effluent from the stripping zone in each cycle. When the gel is saturated with aromatics in the second enriching zone, the vessel is switched to the stripping zone.

Stripping aromatics from the gel is done by a hot paraffinic liquid strippant – such as kerosine or a pentane fraction when treating reformate in the gasoline range, or light straight-run gasoline when treating kerosine.

After segregation of the first stripping effluent as enriching recycle, the aromatics-strippant mixture is separated in the extract still, after which separate fractionating columns separate benzene, toluene and xylenes.

Equipment – Construction materials are conventional. Gel cases may be carbon steel. Heat exchanger equipment may be of any desired material normally used with noncorrosive petroleum stocks. There is little corrosion connected with any step of the process. Gel case instrumentation is conventional in temperature, pressure and flow.

Aromatic Product—Nitration-grade benzene and toluene – after a light acid treatment – may be separated from catalytic reformate of 99+% purities and 99% yields.

Economics – Investment, utilities and chemical requirements for Cyclic Adsorption are given below for recovering aromatics from catalytic reformates. Labor requirements are two or three men per shift.

Cyclic Adsorption capacity, b/sd feed	2000	4000	8000
Investment, $/bbl. feed[1]	$750	$500	$375
Steel, short tons	1600	2200	3200
Admiralty and brass, short tons	17	33	65
Utilities (all capacities)			
Electrical power, kw		104	
Fuel, millions of Btu/hr[2]		18.5	
Cooling water, U. S. gal./min.[3]		905	
Chemicals consumption (all capacities)			
Silica gel life, hrs.		7500	
Strippant, gal./day		108	
Alumina (feed driers) life, yrs.		over 3	

[1]1953 costs – current figures roughly 3-5% higher.
[2]Net heating value.
[3]90°F. with a 30°F. average rise.

Installations – To date there are no commercial Cyclic Adsorption process units in operation.

Licensor—California Research Corporation, Invention Development Dept., 200 Bush St., San Francisco 4, Calif.

Need More Details?

Here's a Selected Reference List

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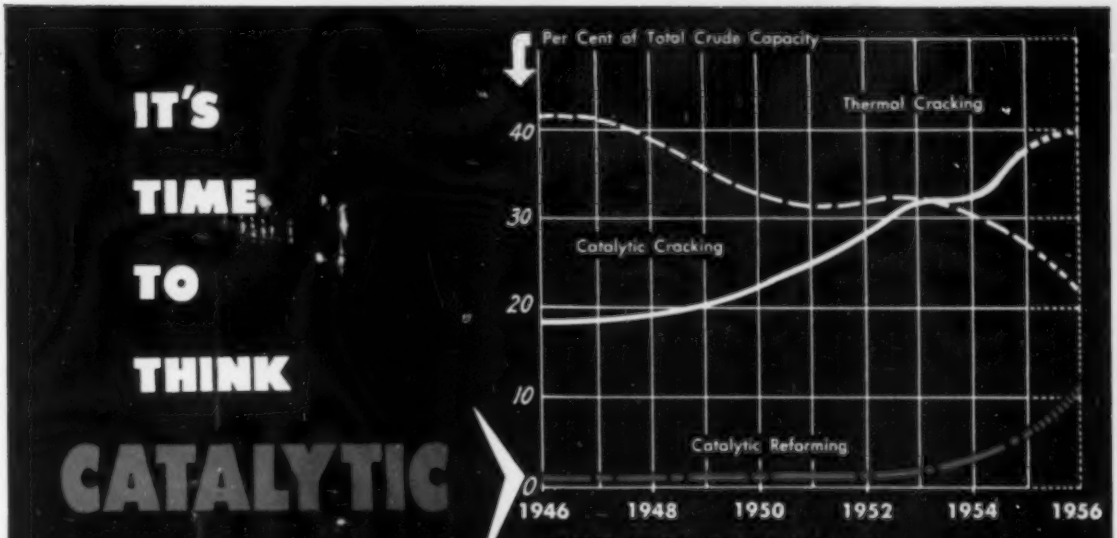

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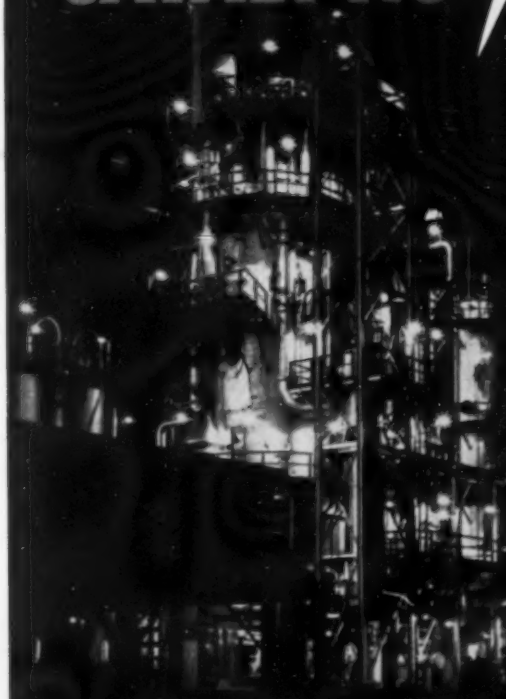

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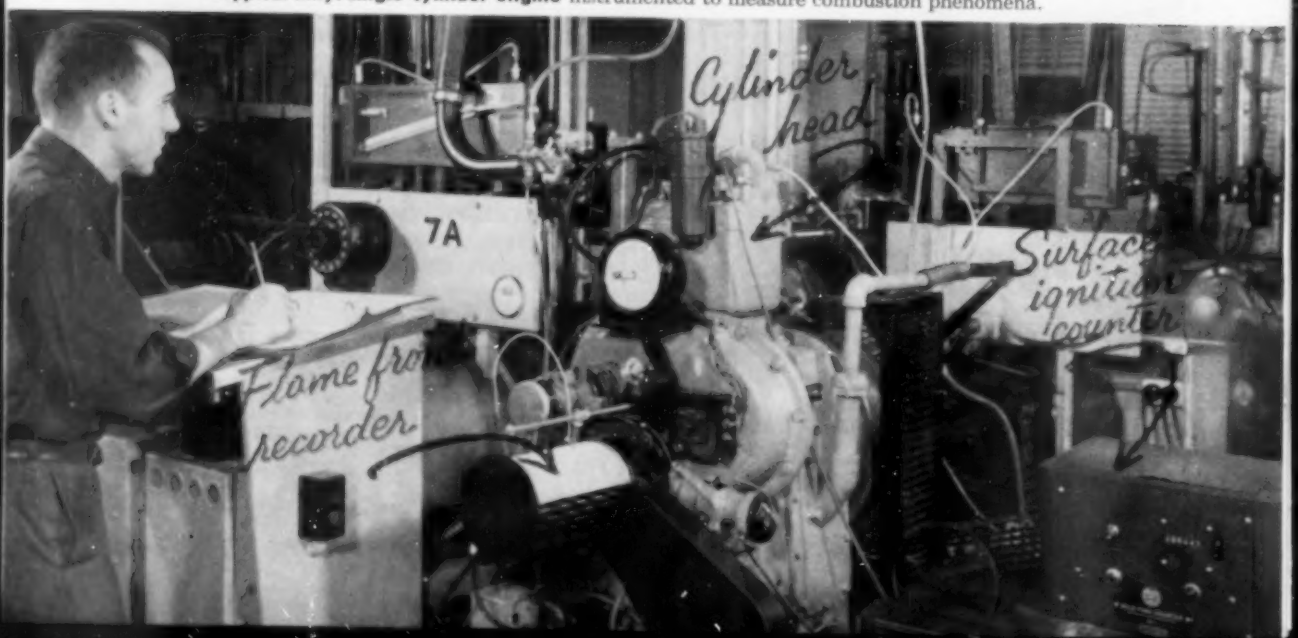

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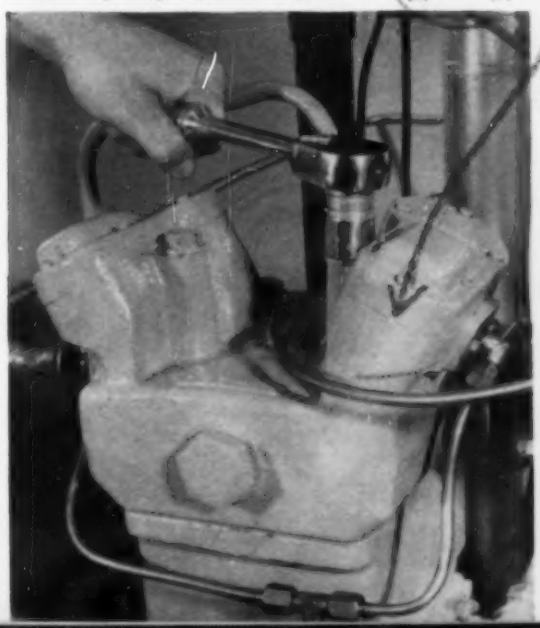
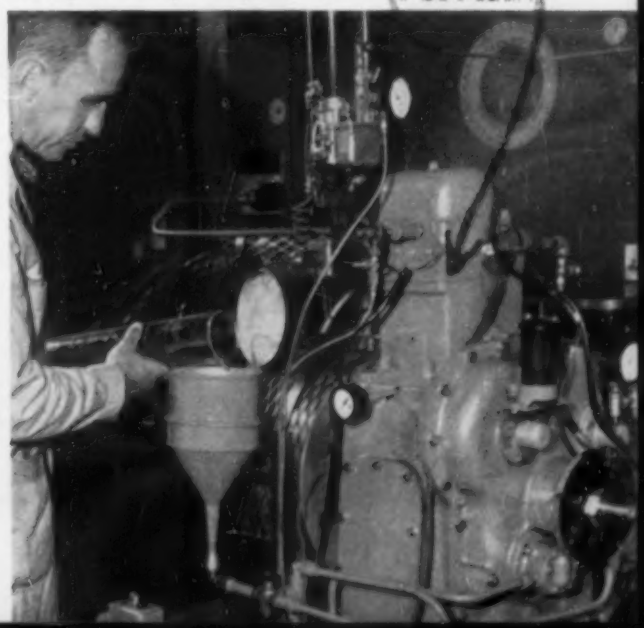
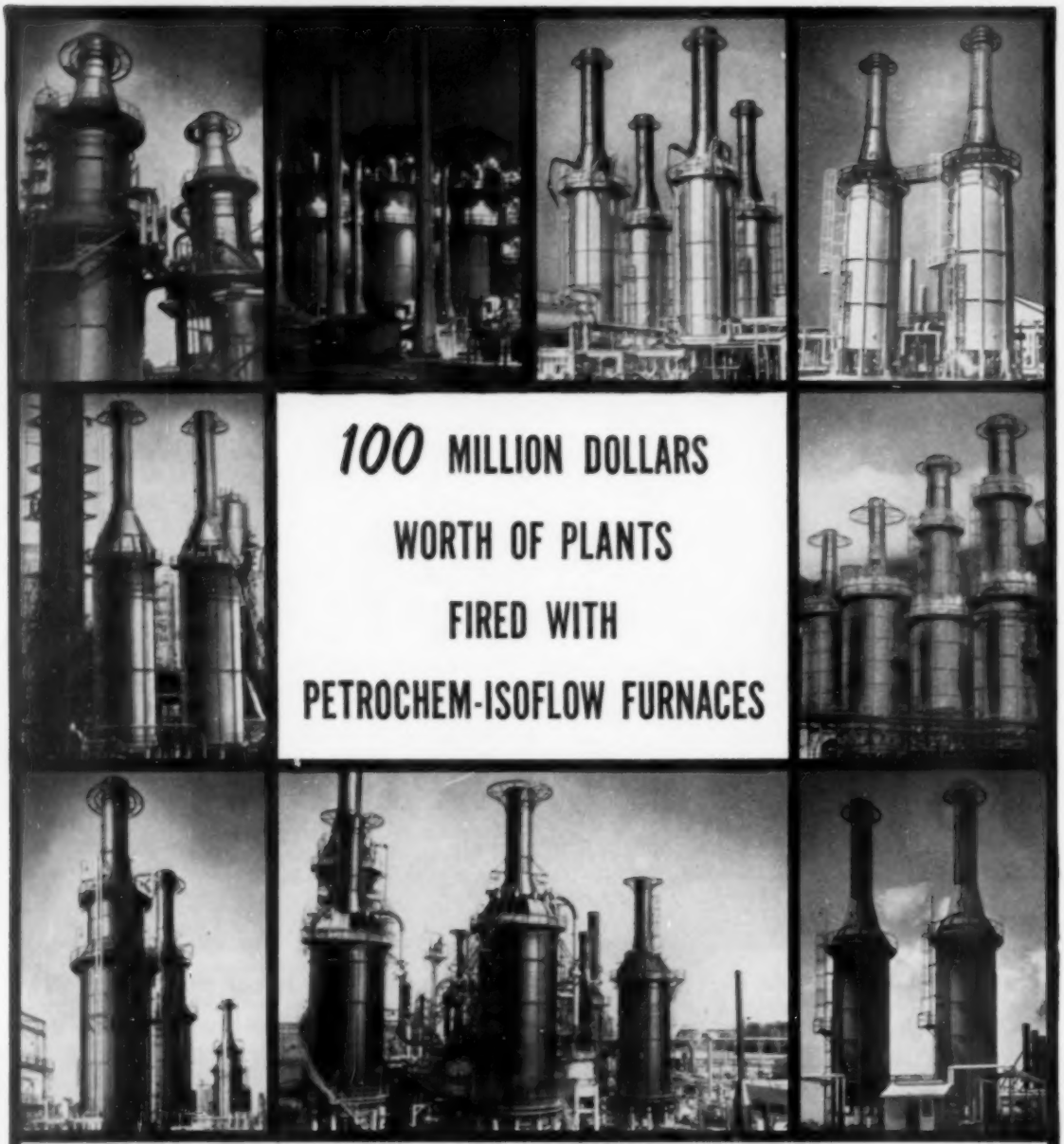
One type combustion chamber used in a popular make of cars is reproduced on an Ethyl single-cylinder engine.



Engine design of another leading car maker is reproduced on a single-cylinder test engine with special cylinder head.





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Petroleum Processing

AUGUST 1955

Petrochemical Section

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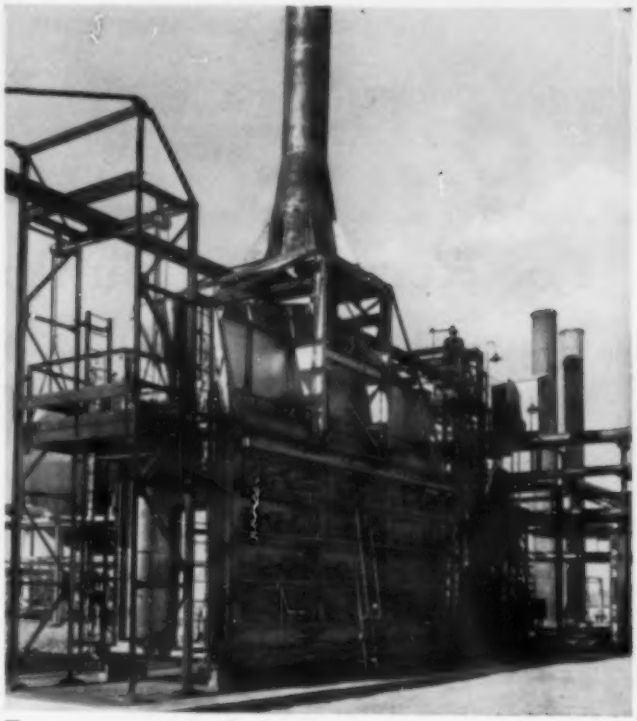

Temperature-Gradient Heater
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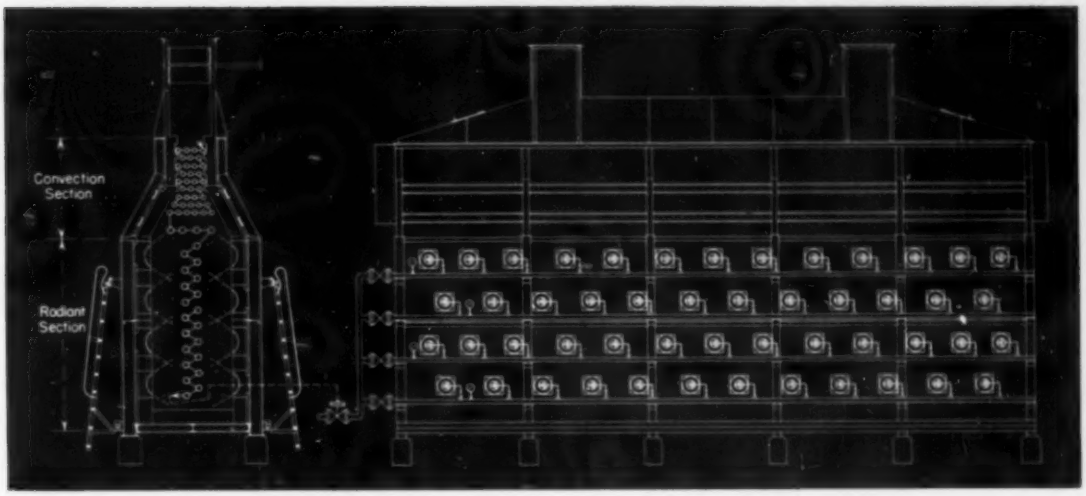


TWO FEATURES REPRESENT DEPARTURE from conventional design in this furnace

Try the gradiation heater for . . .

Economic Ethylene Production

By J. T. KARBOSKY and M. L. HENDERSON, Phillips Petroleum Co., and M. R. KITZEN, Selas Corp. of America

ABOUT five years ago, a new type of process furnace was introduced to the petroleum processing industries. Known as a gradiation, or temperature-gradient heater, its design features included: (1) a tube coil centrally located between two banks of especially designed burners, (2) a multiplicity of burners in each bank, (3) zone control of heat input, and (4) high thermal efficiency.

A development of joint research by Phillips Petroleum Co. and Selas Corp. of America, the furnace has been trade-named the "Selas Gradiation Heater." It has found a diversity of applications including light hydrocarbon pyrolysis, visbreaking, gas oil cracking, vacuum flashing, thermal and catalytic reforming, and various other operations where close control of process variables is required. [1, 2]

Its value in ethylene-producing service has been proved out in a recent series of tests conducted by the Natural Gasoline Dept. of Phillips, tests aimed at checking the following characteristics:

1—High product yields.
2—Economy of operation.
3—Long tube life.
4—Close control of the time-temperature curve.
5—Uniform peripheral and longitudinal heating of the tube coil.
6—Flexibility of operation.

There were two features of the Phillips installation which represented departure from conventional practice in pyrolysis furnace design:

1—The furnace and coil had been designed originally for normal butane pyrolysis.

2—The tubes in the reaction zone were 4.875 in. I.D., larger than usual.

The first feature meant flexibility in operation. Consider a conventional heater which has been designed for a specific purpose and a specific type of feed. If the nature of the charge stock is changed radically, the heat distribution may not necessarily be suitable for optimum operation. Such a variation presented no problem to the new design of heater, because the temperature gradient for optimum operation could be attained by adjustment of control zones to the desired level in accordance with requirements.

The second feature was in the use of the 4.875 in. I.D. tubes, previously considered not feasible from a standpoint of heat transfer and tube economy. The use of large diameter tubes, apart from a pressure drop advantage, depends on the ability to utilize higher heat absorption rates than were previously believed practicable.

In the gradiation heater, heat is applied around and along the tubes, which are equidistant between two radiant walls. The peripheral heat distribution factor is far more uniform than is obtained in conventional heaters, with wall tubes. (See drawing on p. 1213.)[3]

As a result, it is possible to employ higher average heat transfer rates without exceeding the same limiting tube wall temperatures that prevail in heaters of conventional design having equal or lower absorption rates but poorer distribution.

The value of this can be demonstrated by the following numerical example. Consider a coil

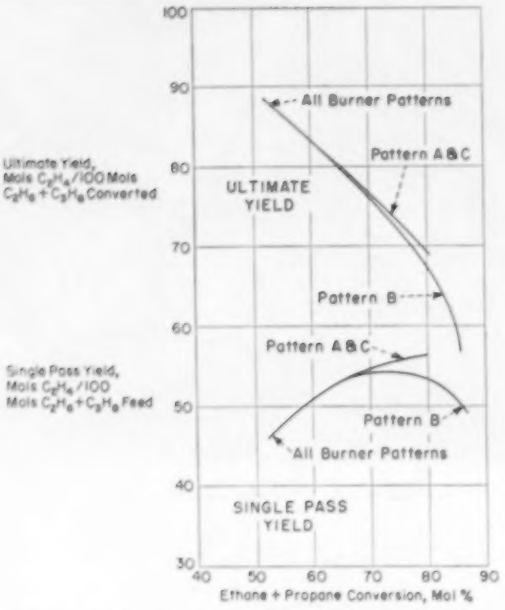


Fig. 1—**EFFECT ON ETHYLENE YIELDS,** single pass and ultimate, by burner pattern and reactant conversion

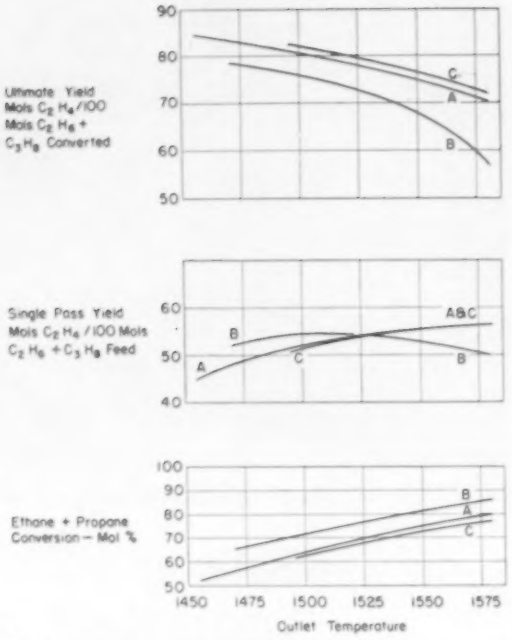

Ultimate Yield Mols C_2H_4/100 Mols C_2H_6 + C_3H_8 Converted
Single Pass Yield Mols C_2H_4/100 Mols C_2H_6 + C_3H_8 Feed
Ethane + Propane Conversion — Mol %
Outlet Temperature

Fig. 2—**EFFECT OF TEMPERATURE** and burner pattern on conversion and on ethylene yields

having tubes 4 in. I.D. by 4.5 in. O.D., properly designed to effect the conversion of a particular feed at a fixed mass velocity. Assume that the terminal points in the reaction zone are maintained constant and a straight line temperature gradient between these points is obtained with an average absorption rate of 11,000 Btu/hr./sq. ft. The equivalent residence time and, therefore, conversion, is a function only of effective tube length.

Assume then a second coil—with the same effective length as the original coil and otherwise operated under the same conditions as before—is available with tubes 4.875 in. I.D. by 5.5 in. O.D. The charge rate must be increased by 49% in order to attain the same mass velocity.

If the average absorption rates in both cases were the same, the additional total heat transferred with the larger tubes—being proportional to the increase in outside surface (22%)—would be inadequate to reach the fixed outlet temperature.

It is therefore necessary to increase the average absorption rate by 1.22, which is the ratio of increased cross-sectional area to increased surface area. The required average absorption rate then becomes 13,400 Btu/hr./sq. ft. When applied, it maintains the equivalence of operating conditions for the two examples so that similar conversions would be obtained. Whereas increased heat absorption rate in any heater would require higher tube wall temperature, the more uniform peripheral heat distribution inherent in the gradiation heater design permits these rates to be achieved with a substantially smaller increase than would be required for a conventional heater.

Although the investment for a structure to house the same length of coil with the larger tubes is about 15% more than the cost of the smaller tube structure, the capacity can be increased by 49%. Moreover, the capacity gain is effected without sacrificing pressure drop, which represents a substantial part of the operating costs.

Following is a description of the ethylene service tests as conducted by Phillips, and a brief description of the furnace used in the work.

The Furnace

The basic principles of the gradiation heater are shown in the drawing on p. 1213. The compact heater utilizes a

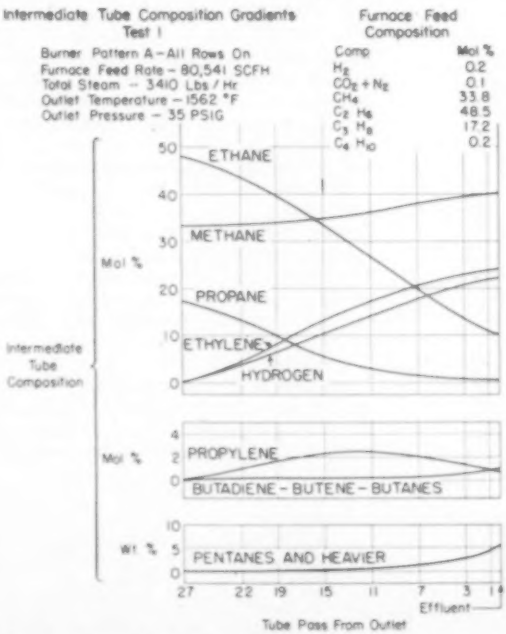
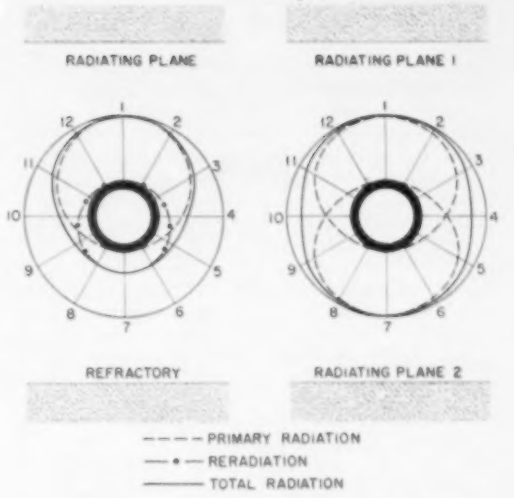


Fig. 3—**EFFECT ON COMPOSITION** of cracked gases in intermediate tubes under conditions shown (Test 1)

multiple system of burners located on opposite sides of the furnace, parallel to and equidistant from the radiant coil. The furnace used for test purposes was equipped with 36 burners on each side arranged in 4 horizontal rows of 9 burners each, equivalent to 4 control zones. Each horizontal row of burners has a 3:1 turndown ratio and is capable of complete and independent control by throttling at the header take-off. The totally inspirating "Duradiant" Burners employed in the heater operate with stoichiometric quantities of air and fuel so that little or no excess air is introduced in the combustion chamber.

The tube coil consists of 34 convection, 5 shock, and 22 radiant tubes. The convection section, subdivided into two parallel banks, consists of 3.5 in. I.D. by 4.0 in. O.D. tubes, 26 ft. in length, mounted on 8-in. centers. Both the shock and radiant sections consist of 4.875 in. I.D. by 5.5 in. O.D. tubes, 28 ft. in length, mounted on 11-in. centers.

The radiant tubes are centrally located in the firebox. The shock and radiant section return bends are enclosed in header boxes thereby decreasing the actual tube length available for heat transfer from 28 to 24½ ft. The shock and radiant tubes are 18-8 Type 304 stainless steel tubing. The convection section consists of 13 carbon steel tubes and 21 Type 304 stainless steel tubes.



HOW HEAT DISTRIBUTION IS IMPROVED with two radiant surfaces (right), as compared with heaters using only one radiant surface (left)

Test Equipment

The test furnace was equipped with a coil effluent temperature control system and a series of combined sample and pressure points. Gas reaction temperatures throughout the coil were obtained by means of chromel-alumel thermocouples encased in 18-8 stainless steel wells in the return bends. A thermocouple was used at each sample point. Composition of the cracked gas could, therefore, be correlated with the actual temperature and pressure throughout the system. All analyses of the feed and cracked gas were made by the mass spectrometer. Flue gases were analyzed by conventional orsat apparatus.

Test Procedure

The feed stock to the furnace consisted of light hydrocarbon vapors from a fractionating column overhead product accumulator. The range of composition varied as follows: methane, 25 to 30%; ethane, 50 to 65%; and propane, 10 to 20%. The feed volume averaged approxi-

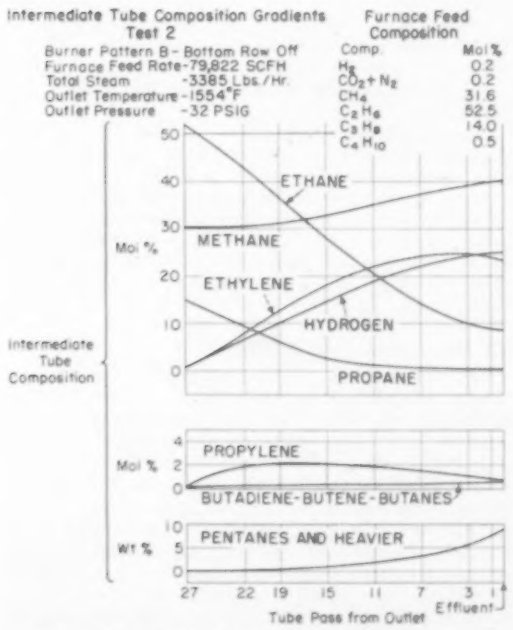


Fig. 4—Same as Fig. 3 but for conditions under Test 2

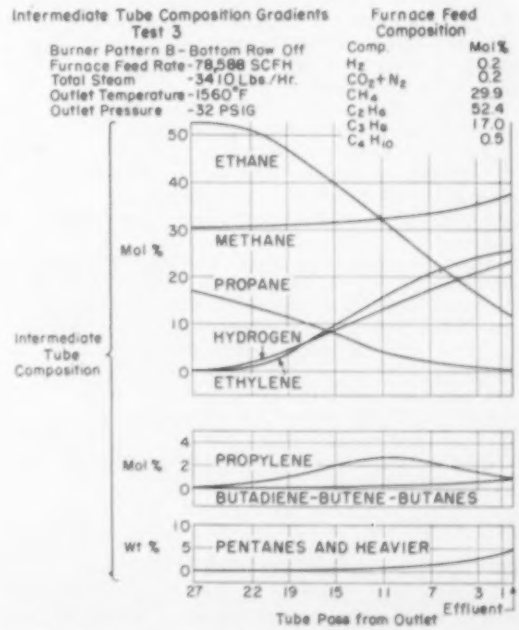


Fig. 5—Same as Fig. 4 but for conditions under Test 3

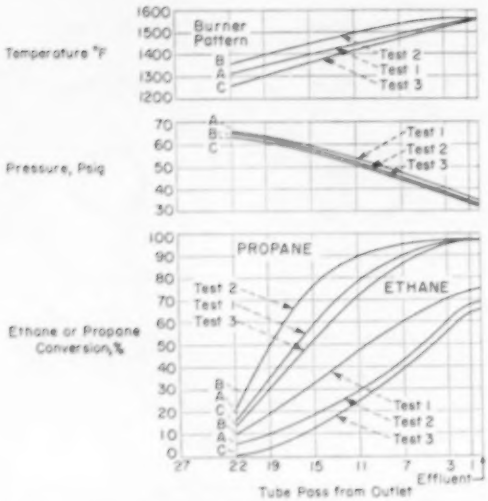


Fig. 6—**CRACKED GAS COMPOSITIONS** as related to intermediate tube temperature, pressure and conversions

mately 80,000 cu. ft./hr. and varied as much as 10%. Naturally, any change in fractionating column operation was reflected in a change of furnace feed composition and volume.

The pyrolysis data obtained in these tests is not directly comparable to any previously reported in literature.[4, 5] Consequently, comparison of ethylene yields from this report with results from other sources should be carefully made on the basis of equitable feed stock composition. It should also be noted that the data presented in this paper are average results and represent a great number of test runs. The actual data are so voluminous that their inclusion in this paper is not practical.

In order to insure a relatively high mass velocity in the tube coil, sufficient steam was injected with the feed to maintain at least 17.5 lbs./sec./sq. ft. The test period lasted 45 consecutive days and was terminated only by other plant requirements.

The conversion-ethylene yield correlations were obtained by changes in the tube coil outlet temperature. The outlet temperatures were varied in increments of 10 to 15° F. and an ethylene yield curve established over a wide range of conversion. Reproductions of conversion and ethylene yield at identical outlet temperatures were well within 3%.

The time-temperature relationship was established by selectively altering the firing pattern of the furnace. This was easily accomplished due to the multiplicity of burners. Any number of burner arrangements can be employed. However, only the three burner arrangements were selected which would provide the intermediate, maximum, and minimum residence times operating with: (A) all burners on, (B) the bottom row off, and (C) the top row off. Outlet temperatures were varied to obtain overlapping conversion ranges for each pattern, with a maximum outlet temperature of 1575° F.

Test Results

(A) Conversion and Ethylene Yield

Ethylene yields, expressed as mols of ethylene per 100 mols of ethane plus propane feed, are shown in Fig. 1 in composite form for the three burner patterns employed. Owing to the temperature limitation of 1575° F., it was impossible to obtain a well-defined peak ethylene yield with burner pattern A (all burners on) or burner pattern C (top row burners off). The peak yield for burner pattern B (bottom row burners off), occurring at approximately 72% ethane plus propane conversion, is 54.5 mols/100 mols ethane plus propane feed. The maximum yields attainable under test conditions, but not necessarily the peak yields, for burner patterns A and C are 56.5 mols/100 mols ethane plus propane feed.

It should be noted that a portion of the ethylene product originates from propane destruction; therefore, these curves do not represent the same yields that would be obtained if high purity ethane were used as a feed stock.

(B) Effect of Burner Pattern and Temperature

The yield curves shown in Fig. 1 indicate that identical molal ethylene yields are obtained under all burner pattern operations below ethane plus propane conversions of 65%. Both burner patterns A and C show identical yields of ethylene above 65% reactant conversion, increasing to the limiting outlet temperature.

The burner pattern B ethylene yield peaks at 72% conversion and decreases at higher conversion. Thus, it can be inferred that the furnace feed rate, including feed inerts, was somewhat above optimum for patterns A and C, while below optimum for pattern B.

If the throughputs had been adjusted to achieve peak ethylene yields at 1575° F. outlet temperature for each pattern, though pattern B would remain at slightly lower yield, greater net production of ethylene would result by virtue of a higher charge rate.

The effects of temperature and burner pattern on conversions and ethylene yields are shown in Fig. 2. This is perhaps the most striking example of the operating flexibility of the heater. The ability of burner pattern B to produce ethylene yields almost equivalent to those of either burner pattern A or C, but at reduced temperatures, is clearly demonstrated.

By considering operation at constant conversion levels, additional interesting conclusions become evident. In the ethane-propane conversion range above 80%, a distinct ultimate and per-pass yield advantage exists for operation at the highest permissible temperature and shortest residence time (Pattern C).

At ethane-propane conversions between 70 and 80%, the higher per-pass and ultimate yields available through high temperature and shorter residence times (burner patterns A and C) should be evaluated in the light of increased coil service life for pattern B by virtue of lower operating outlet temperature. In the conversion range below 70%, the equivalence of yields indicates the use of long residence time since other temperature effects are not apparent.

(C) Intermediate Tube Coil Results

In order that the reaction mechanism can be more readily understood, complete intermediate tube data were obtained for each of the burner patterns at near identical outlet temperatures and constant feed rates. The results of this study are shown in graphical form in Figs. 3 to 6 inclusive. Cracked gas compositions throughout the radiant sections of the tube coil, shown in Figs. 3 to 5, are expressed as mol per cent of the cracked gases at the specified tube position. The pentanes and heavier components, consisting mainly of benzene, are somewhat difficult to analyze; therefore, this fraction is shown plotted in terms of weight per cent of the furnace hydrocarbon feed rate.

The cracked gas composition gradients are related to the intermediate temperatures, pressures, and conversions as shown in Fig. 6. The data shown by these curves are self-explanatory; therefore, a detailed discussion will not be made. These data are presented merely to illustrate the extent to which furnace operation can be altered by burner pattern changes so that the point of incipient cracking is shifted through the coil.

(D) Operating Characteristics

The over-all pressure drop is characteristically higher in this heater than is normal for heaters of conventional design in ethylene service. This is attributed to the belief of Selas engineers that a substantial amount of convection preheat should be provided in order to permit introduction of the reactants into the radiant section at temperatures just below the cracking point. By so doing, not only is good thermal efficiency assured without relying on extraneous streams to recover heat, but all control zones are thus available to provide maximum operating flexibility in the critical reaction section. The Selas design consequently employs more total tubes with a resulting higher pressure drop than other heaters.

Heat absorption rates in this heater varied with the burner pattern in use. With burner pattern B, the heat absorption rates in the radiant section progressively decreased from approximately 15,000 Btu/hr./sq. ft. in the initial stage of the reaction coil to practically zero in the final stage.

Burner pattern C resulted in somewhat more uniform heat transfer rates which varied from 11,000 to 8,000 Btu/hr./sq. ft. throughout the length of the radiant coil.

Use of burner pattern A resulted in heat transfer rates which were intermediate between the other two patterns.

These transfer rates are somewhat lower than would be expected; however, it can be partially explained by the relatively low mass velocity used throughout the test program.

The over-all thermal efficiency* of the furnace averaged 62% with stack gas losses approximating 30% of the total heat input. Convection and radiation from the header boxes comprise the remaining heat losses. Current Selas designs which put the entire tube coil, including return bends, in the fire box are expected to result in thermal efficiency approaching 70%. Such design is not undesirable from the viewpoint of coil accessability since the furnace ordinarily operates for long periods without requiring maintenance.

At 75% ethane conversion, 30-day operating periods can be safely attained without difficulty. At 65% ethane conversion, 60 to 90 day runs can be realized providing that complete burnouts are made after each operating period. It is beyond the scope of this paper to estimate tube life. It is significant to note, however, that after 20 months operation, the tube coil in this test furnace has not revealed any appreciable wear.

Three years ago, the first gradiation heater was placed in light hydrocarbon pyrolysis service producing ethylene from essentially pure ethane, propane or mixtures thereof. A review of the operations of this heater reveals continuous on-stream runs of up to 160 days duration. The coil, at the end of this period, was still in excellent condition and with no apparent signs of coke. The original type 310 stainless steel tubes in the radiant section are still in service.

* Thermal efficiencies are based on the gross heating value of water saturated fuel as determined on a Cutler-Hammer calorimeter at 30 in. Hg and 60° F.

Meet the Authors

J. T. Karbosky, a process engineer in the natural gasoline department, Phillips Petroleum Co., Bartlesville, Okla., is concerned with the application and design of light hydrocarbon thermal cracking units, alkylation, isomerization, and other related processes.

Born in New Jersey, he was graduated from Missouri School of Mines and Metalurgy in 1942 with a B.S. in chemical engineering. Prior to joining Phillips in 1945, he was with Cooperative Refinery Association as a process engineer and a shift supervisor. A bachelor—but willing to change the status—Mr. Karbosky enjoys all sports but participates in the less strenuous ones, fishing, hunting, and poker.

Mr. Karbosky

Miles L. Henderson is also a process engineer in Phillips' natural gasoline department, but is located at Borger, Texas. Since joining the company in 1952, he has devoted considerable time to process work in the production of ethylene from light hydrocarbon cracking.

Prior to becoming associated with Phillips, Mr. Henderson was a plant engineer for the Southwestern Public Service Co. He is a graduate of Kansas State College with a B.S. in mechanical engineering. His favorites among non-vocational activities are sports and photography.

Mr. Henderson

Maurice R. Kitzen has been engaged in tubular heater design as a process engineer with Selas Corp. of America since March, 1952. A graduate of Rensselaer Polytechnic Institute, he served on active duty in the U. S. Naval Reserve from 1945 to 1946 before earning an M.S. in chemical engineering from the University of Pennsylvania in 1947.

Mr. Kitzen was an assistant chemical engineer in the research and development department of Atlantic Refining Co. from 1947 to 1952 when he joined Selas. He became a registered Professional Engineer in 1954.

Mr. Kitzen

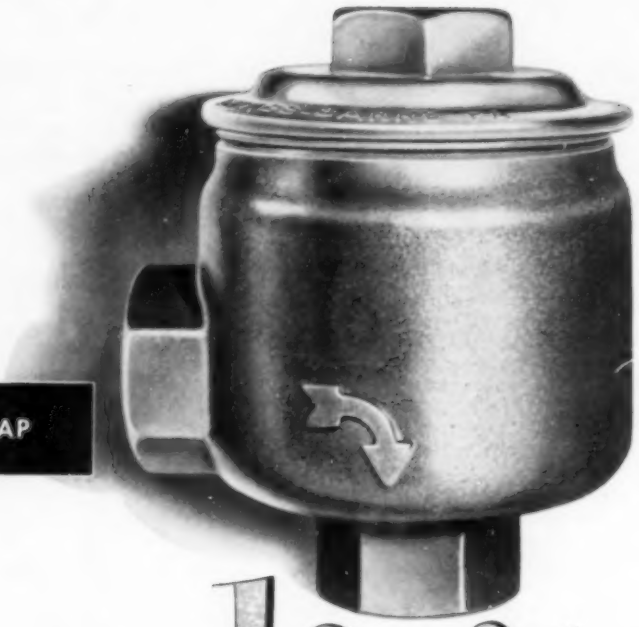
(1) "Visbreaking High Vacuum Residua," Allen, J. G., Little, D. M., and Waddill, P. M., Petroleum Processing, Vol. 6, No. 6, pp. 612-615, June, 1951.

(2) "New Radiant Type Heater," anon., Petroleum Processing, Vol. 6, No. 6, pp. 616-617, June, 1951.

(3) Kreipe, T. F., *Trans. American Society of Mech. Engrs.*, Vol. 76, No. 3 (1954).

(4) "Ethylene Production by Cracking of Propane-Ethane Mixtures," Buell, C. K., and Weber, L. J., Petroleum Processing, Vol. 5, Nos. 3 & 4, pp. 266-272 and 387-391, March & April, 1950.

(5) Schutt, H. C., *Chemical Engrg. Prog.*, Vol. 43, No. 3 (1947).



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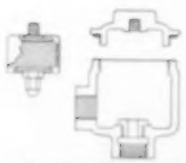

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COMPLEX separations are required in the recovery of pure chemicals from the crude product of partial oxidation of hydrocarbons. These are not feasible by ordinary distillation.

Mixtures of close boiling compounds, often members of the same homologous series, and mixtures containing binary and perhaps ternary azeotropes are encountered and must be resolved. Straight fractionation would separate the close-boiling compounds although an impractical number of plates is required, but is useless for azeotropes.

The azeotropes of 11 oxidation products limited to the C_1 through C_4 range, plus water, in a crude reactor product are shown in the table below, in order of increasing boiling points. Listed are just about one fourth of the possible constant-boiling mixtures present in a crude reactor product.

Straight fractionation to recover one product from the 11-compound mixture would be out of the question. All the methyl-ethyl-ketone, for instance, might azeotrope with methanol at 64° C, therefore a cut made at the boiling point of MEK, 80° C, might contain only tert-butyl alcohol, isopropyl alcohol and water.

Differences in polarity between components of the mixture are necessary for the successful employment of azeotropic or extractive distillation. Because of molecular dissimilarities, the homologous groups of oxidation products can be arranged in order of increasing polarity, as follows:

1—Esters
2—Oxides
3—Aldehydes
4—Ketones
5—Acetals
6—Alcohols

Also, in any one group the compounds of lowest molecular weight are more polar than the highest members of the series, straight-chain molecules are more polar than those with branched chain structures, and olefinic compounds more polar than corresponding paraffins.

An entrainer, or solvent, is used to alter the relative volatility of components in the feed to azeotropic or extractive distillation, the direction in which volatility is changed depending upon the polarity of the solvent. The relative volatility of the more polar component will be lowered, and the less-polar compound taken overhead, in extractive distillation using a highly polar solvent. If a non-polar solvent is used this volatility relationship is reversed and the highly polar compound recovered overhead.

Theoretically it is possible to make a given separation with either a polar or non-polar solvent but, in practice, it is desirable to select a solvent which will work in the same direction as the natural volatility of the desired components to form an azeotrope or suppress the volatility of the higher boiling compound. The acetal of formaldehyde and methanol—methylal—forms an azeotrope with methanol which boils at 41.8° C. Methylal boils at 42.3° C. and is much more volatile than the methanol, which boils at 64.7° C., and is more polar.

A polar solvent is required to suppress the volatility of methanol in an extractive distillation. It has been found that the separation can be made with as little as 30 wt.-% of water, a polar solvent. Methylal is taken overhead and the methanol and water removed as kettle product. The methanol is then easily recovered from the water by simple distillation in a second tower.

The normal volatility of the feed components would have to be completely reversed and methanol taken overhead if a non-polar solvent could be used effectively. While possible, the required solvent concentration would be too great for practical application.

The relative volatility is almost unity and the polarity of the solvent is not too important when close-boiling compounds are to be separated. As an example, the normal volatility of n-propyl alcohol relative to allyl alcohol is 0.94. In the presence of water the relative volatility becomes greater than unity. A virtually complete separation is possible on a 60-tray extractive distillation column, using 75 wt.-% water on the trays. N-propyl alcohol is the overhead product, even though it is the least volatile component in a non-aqueous mixture of the two compounds.

Both extractive and azeotropic distillation in sequence is often necessary to recover a pure product from a crude fraction.

A case in point is the recovery of part of the methyl-ethyl-ketone from a cut containing also the impurities, methyl-tetrahydrofuran, formals and acetals.

First, an azeotropic distillation with n-hexane is used to remove all but a small portion of the impurities. The azeotrope is taken overhead at 65° C. and the MEK recovered by extraction with water. The remaining impurities, acetals, are removed by water extractive distillation with approximately 60 wt.-% water on the trays. The acetals are suppressed by the polar solvent, water, and the azeotrope of

Boiling Points of Selected Oxygenated Chemicals and Their Binary Azeotropes

Pure compound or binary azeotrope	Normal boiling point °C	°F	Pure compound or binary azeotrope	Normal boiling point °C	°F
Acetone; methyl alcohol	55.5	131.9	Isopropyl alcohol; water	80.3	176.5
Acetone	56.5	133.7	Isopropyl alcohol	82.5	180.5
Methyl alcohol; methyl-ethyl-ketone	63.5	146.3	tert-Butyl alcohol	82.9	181.2
Methyl alcohol	64.7	148.1	n-Propyl alcohol; water	87.0	188.6
Methyl-ethyl-ketone; water	73.4	164.1	sec-Butyl alcohol; water	87.5	189.5
Ethyl alcohol; methyl-ethyl-ketone	75.7	168.3	Isobutyl alcohol; water	89.8	193.6
Methyl-ethyl-ketone; isopropyl alcohol	77.9	172.2	Water; n-butyl alcohol	92.7	198.9
Ethyl alcohol; water	78.2	172.8	n-Propyl alcohol	97.8	208.0
Ethyl alcohol	78.4	173.1	sec-Butyl alcohol	99.5	211.1
Methyl-ethyl-ketone; tert-butyl alcohol	78.7	172.7	Water	100.0	212.0
Methyl-ethyl-ketone	79.6	175.3	Isobutyl alcohol	108.0	226.4
Tert-butyl alcohol; water	79.9	176.0	n-Butyl alcohol	117.5	243.5

MEK-water removed overhead. The MEK is subsequently recovered by drying, using pentane extraction.

Both polar and non-polar solvents can be used in a series of steps to purify acetone, which is present in partial oxidation products as a ternary azeotrope with methanol and tetramethylene oxide, a cyclic ether. The ternary mixture can be broken by extractive distillation with water, which is strongly polar. The relative volatility of methanol is sufficiently lowered so that the binary azeotrope of acetone and tetramethylene oxide may be distilled overhead in the extractive distillation column.

The azeotrope of acetone and tetramethylene oxide is broken by forming a lower-boiling azeotrope of acetone with pentane, boiling at 32° C. The acetone is further purified by extraction and distillation. The methanol kettle product of the extractive distillation column is purified by simple distillation.

Polar and non-polar entrainers may be combined in one tower to separate close-boiling compounds. An example is the mixture of n-propyl alcohol and sec-butyl alcohol, the normal volatility of the n-propanol to the sec-butanol being 1.09. Separation can be effected by forming a ternary azeotrope by adding a 4:1 ratio of water in methylcyclohexane to the mixture of alcohols.

Separation of the overhead product is simplified by the formation of two layers, a desirable solvent property in azeotropic distillation. The disadvantages of the solvents employed are the high latent heat of vaporization of water and the complicated separation of water from the n-propyl alcohol, which together form an azeotrope. However, over 90% of the n-propanol can be recovered by this method.

Solvent selection is based not only on its polarity and ability to alter relative volatility, but also on cost, stability, non-corrosiveness and non-toxicity. The ease of separating solvent from the desired product and the latent heat of evaporation also must be considered in azeotropic distillation problems.

Vapor-liquid equilibrium data covering a broad range of concentrations of selected solvent and the key components are used to determine optimum solvent concentration, reflux ratios and number of trays required in the design of an efficient tower.

Solvent concentration is a variable in extractive distillation, while the solvent concentration on the trays is necessarily limited in azeotropic methods and can be varied only by changing solvents and, to a minor extent, by changing pressure on homogenous azeotropes.

Many mixtures are of such complex nature that it usually is wise to check a calculated design in a pilot plant before a commercial installation is made. In fact, some of the towers for the azeotropic and extractive distillations encountered in a hydrocarbon oxidation plant must be designed entirely from pilot plant data.

The purification of aqueous formaldehyde solutions is a case in point. Formalin, produced by the partial oxidation of hydrocarbons, contains impurities which are present in minute quantities even after several distillations. These impurities make known their presence by adverse effect on such product specification tests as residual odor and the development of color with sulfuric acid treatment.

The amount of these impurities is too small to permit quantitative analysis, so basic equilibrium data are impossible to obtain. Such separations are developed entirely in laboratory and pilot plant columns. Optimum solvents and operating conditions are evaluated by finding the effect of each of these as a variable on specification tests of the finished product.

The problem of purifying formalin was approached in this manner. It was found that extractive distillation with a polar solvent, such as ethylene glycol, would carry the impurities out the base of the tower. The formalin product taken overhead passed the critical specification tests.

Searches for new applications of azeotropic and extractive distillation do not end with the design and construction of a new plant. A continuing study of purification problems easily pays for itself in a hydrocarbon oxidation plant by revealing more efficient methods for isolating old products and in showing how new products can be recovered from mixtures previously considered worthless.

Acknowledgment

The preceding article has been adapted from the paper, "Applications of Azeotropic and Extractive Distillation in the Production of Petrochemicals," presented by W. C. Hopkins and J. J. Fritsch, Celanese Corp. of America, at the Houston National Meeting, American Institute of Chemical Engineers, May 1-4, 1955.

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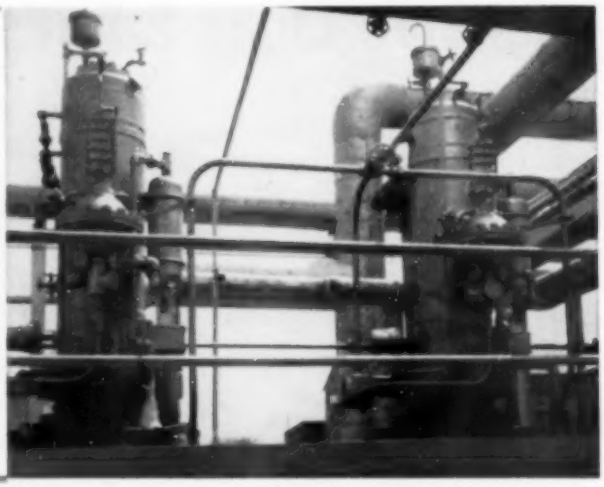

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And Now—Petrochemical Residences

THESE men are making load-bearing, exterior house walls of 3 x 12 in. boards, 9 ft. long. Boards weigh only 4½ lb. each, and are made of a new foam type polystyrene called Styrofoam.

The interest of this development is discussed on p. 1101 ("Add New Uses for Petrochemicals—Structural Material for Housing").

First house to be built like this has gone up recently in Houston. Walls, flooring, and roof are of Styrofoam. Boards are placed on edge, seams staggered. Cold-setting asphalt cement bonds only the vertical seams and where the boards touch wood studs. Boards are pinned together with wood skewers. Finish coat is 1-in. thickness of portland cement on inside and outside. Such walls have more rigidity than usual frame construction, though not as much as brick veneer, cinder or concrete block.

Do You Know These Words?

By B. H. WEIL
Manager, Information Services
Ethyl Corp. Res. & Engrg. Dept.
Detroit, Mich.

A regular department intended to help administrators and operating men alike keep abreast of technical names and processes in the petrochemical field.

Isosebacic Acid

Isosebacic acid, pronounced "**eye**-so-sea-**bass**-ick **ass**-id," is a coined trade name for a mixture of three 10-carbon-atom dicarboxylic acids (organic acids containing two -COOH groups, where C is carbon, O is oxygen, and H is hydrogen). This mixture of isomers of sebacic acid (previously a castor-oil derivative) is said to have similar properties to sebacic acid itself, which is a straight-chain compound containing carboxyl groups at both ends, having the formula COOH·$(CH_2)_8$·COOH. Sebacic acid is a colorless solid which melts well above the boiling point of water; it is present in Isosebacic acid to the extent of 6-10%.

Interest in Isosebacic acid, at present available only in pilot-plant quantities, is centered around its synthesis from low-cost, generally available raw materials (butadiene and sodium)—materials which would be far more available in case of war than castor oil. Moreover, the Isosebacic acid is already cheaper than sebacic acid, and not much more expensive than adipic acid. Potential markets include use in the synthesis of plasticizers, nylon fibers and plastics, and synthetic lubricants. The latter field—that of the diester synthetic lubricants—is said to be particularly intriguing, since it is known that dioctyl sebacate has advantages over the more-available adipates (diesters of adipic acid).

Isosebacic acid rates as a petrochemical by virtue of its synthesis from butadiene, which in turn is produced by the catalytic dehydrogenation of butane and/or butylenes from refinery gases or LPG-butane. Research and sales development will determine how deeply this new chemical will penetrate into the fields of the dibasic acids.

Polyethylene Terephthalate

Polyethylene terephthalate, pronounced "**pahl**-ih-**eth**-ih-lean tehr-**ef**-thahl-ate," is rapidly becoming a high-volume petrochemical. Better known to the public in the form of Dacron and Terylene synthetic fibers, Mylar polyester film, and Cronar photographic-film base, this material is now being produced in the United States, Canada, and Great Britain, and may soon be produced in several European countries.

As implied above, polyethylene terephthalate finds it chief uses at present in the manufacture of synthetic fibers, films, and photographic-film base. The fibers are known for their exceptional crease resistance, wet strength, and small absorbtion of moisture (quick drying). The films have numerous valuable properties for use in recording and industrial tapes, thermal insulation, etc.—high tensile, dielectric, and impact strengths; chemical inertness; and dimensional stability.

As a base for photographic film, the material is as safe as acetate film and is considerably more durable and dimensionally stable; for example, it has twice the tear resistance of other films, and its toughness may make possible a 20% reduction in the thickness of motion-picture film.

Polyethylene terephthalate is prepared from dimethyl terephthalate (a *para*-xylene derivative) and from ethylene glycol (an ethylene derivative). Both are petrochemicals, since *para*-xylene is being separated from naphthas (chiefly catalytic reformates) by at least four petroleum companies, while ethylene is being produced by numerous companies via separation from refinery cracked gases or deliberate cracking of refinery and LPG hydrocarbons.

A recent Schoellkopf Medalist, E. F. Izard, has pointed out that only one other material—cellulose acetate—is being used in all three major fields (textile fibers, film, and photographic-film base). Since "polyethylene terephthalate products are far superior to cellulose acetate in each of these applications," increased use is certainly to be expected.

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ATLANTIC *It's the Catalyst that counts*

Three Advantages in this Steam Cleaning Nozzle

AT FIRST glance, that steam cleaning hoze nozzle shown above doesn't seem much different than hundreds of others to be seen around any refinery or petrochemical plant. Yet this one is probably the safest and most convenient to use nozzle we've seen in a long time.

Developed and in use at Dow Chemical Co.'s Freeport, Texas, petrochemical plant, it has three distinct "plus" factors that make it worthwhile taking a closer look at it. It consists of a standard pipe Tee, to one arm of which is connected a long and light piece of pipe bent near the business end and formed into a nozzle. Another length of pipe (or it could be a rod) sealed at the end is screwed into the other arm of the Tee, and then there's a standard connection for attaching a steam hose to the third arm of the Tee.

The first advantage to this arrangement over the conventional method of simply fastening a nozzle to the end of the steam hose is convenience in using. The bent nozzle (about 20 or 30°) can get into places where otherwise the operator might have to lift the hoze and nozzle over his head—or virtually get down on his stomach—to reach in and get the steam where it will do the most good.

Secondly, the operator doesn't have to be right in the middle of the steaming hot work. He avoids getting steam in his face and splatters from the job. If splashes or slop-overs do occur, he has a chance to keep clear and avoid possible injury from cleaning compounds, scalds, or burns.

Thirdly, the steam hose will last longer. It hangs down from the nozzle and is not constantly being flexed and strained as the operator moves the nozzle around. More importantly, however, is the fact that the operator doesn't have to touch it except for connecting and disconnecting. If it should break at the connection, or if the connection should leak; the operator is not exposed to possible injury from the release of live steam. Finally: the handle is not carrying hot steam and is therefore more comfortable to hold, even though gloves are worn customarily on jobs of this type.

Solution to a Catalyst Flow Problem

THE Pure Oil Co. refinery at Lemont, Ill., has one of the first UOP Fluid catalytic cracking units installed in the Chicago area. During the initial start-up of this unit, a power interruption unexpectedly shut down the air blower, creating a situation wherein the pressure in the regenerator forced the catalyst back up into the air blower discharge line.

Normally, a flapper type check valve in this air line is supposed to prevent such back-up of catalyst to the air blower during periods of reversed air flow. This air line check valve is mounted in a vertical position, and when the flapper is in full-open position it tends to balance or stick in

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YOU get even, no glare, Low Cost Lighting with Jerguson Illuminators . . . the improved illuminators that are unexcelled for gages, rotameters, etc. They give you ideal illumination with safety . . . and make possible faster, easier, accurate reading.

Jerguson Illuminators use the principle of solid wedge lighting to give you *clear, even lighting, without bright spots*. Light flows through the plastic wedge and is reflected evenly. A single bulb gives you better illumination at a cost so low that savings quickly pay for the illuminator.

Jerguson Illuminators are approved by Underwriters' Laboratories and are built in accordance with their Standard for Electric Lighting Fixtures for use in hazardous locations for Class 1, Group D Services. Made in a variety of sizes; also available in a non-explosion proof model.

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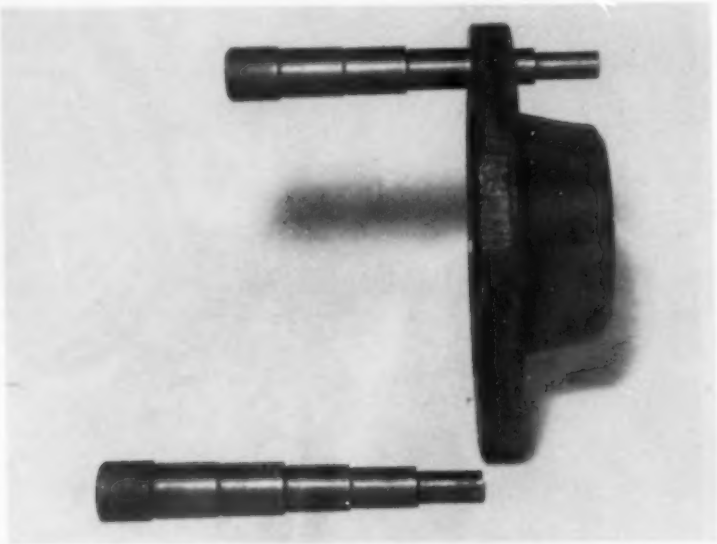
Pétrole Service, Paris, France

this vertical position long enough to allow the catalyst to flow back past it. (Note: later models of this Fluid catalytic cracking unit have the check valve mounted horizontally and are not prone to a delayed action).

The remedy for the balky check valve was to weld little "stops"—small pieces of metal—inside the valve to keep the flapper from ever reaching a completely vertical position when at full-open position. Since these stops have been installed, Pure has had no reoccurrence of catalyst backing up into the line to the air blower.



"STEPPED" PLUGS, used in pairs, permit operator to . . .

MAKE FASTER ALIGNMENTS, with level gage, prior to welding

Plugs Speed Flange Welding Line-up

MUCH time can be lost in the alignment of pipe flanges prior to their being welded onto pipe ends. Standard alignment procedures have included the usual time-consuming measurement of flange center lines, or attempts to "aim" the upper flange holes against a levelling gage.

Socony Mobil Oil Co.'s East Chicago, Ind., refinery welding shop has for several years speeded pre-welding flange alignment by means of "stepped" plugs, as shown in the photographs. These plugs have several

UNDER PRESSURE? TRY 4500 PSI AT 1150 F

There's a new concept in big boiler design: The Universal Pressure Steam Generator. It operates either below the critical—3206 psi—or smashes through the pressure barrier. A unit now being built has a design pressure of 5500 psi, delivers steam at 4500 psi and 1150 F. It's a "once-through" unit; put water in one end of a tube and steam comes out the other, without using a steam drum.

When B&W engineers designed this new boiler they turned to their own metallurgical and tubular products experience with alloys for pressure and temperature service to devise the tubing complex that is the heart of the unit. The chart shows the variety of analyses in sizes from 1-inch O.D. to 2½-inch O.D. and wall thicknesses from 0.10-inch to 0.55-inch.

Carbon Steel • Carbon Moly
Croloy ½ • Croloy 1
Croloy 1¼ • Croloy 2¼
Croloy 3M • Croloy 9M
Croloy 18-8

The best way to avoid operating under *personal* pressure on any job is to call for B&W Pressure Tubing. There's a grade, size, length and wall for virtually every pressure, temperature and corrosion resistance requirement. *Write for Technical Bulletin 6. PP.*

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Milwaukee, Wis: Seamless Welding Fittings

TA-5028(P)

(To obtain more data on advertised products see page 1252)

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"There's an Airetool Tube Cleaner and Tube Expander for Every Type of Tubular Construction."

steps so as to allow one plug to fit any standard flange bolt hole from ½ to 1⅛ in. Other plugs have been made available to fit the large hole size ranges.

In use, two plugs of the same size are selected. These plugs are inserted as far as they will go into two adjacent flange holes at the top of the flange—the flange being held vertical with respect to the welding bench. Plug insertion will be the same for both plugs, as they are both pushed in to the "step" with the diameter matching the flange holes.

After the plugs are inserted, a levelling gage is laid across them. Then the flange is slowly rotated until the level gage bubble is centered. Now the flange is in line and is ready to be welded onto its section of pipe. The whole operation is much faster than any other method Socony has tried.

How to "Sound Proof" A Big Maintenance Shop

The new main shop at the Big Spring, Texas, refinery of Cosden Petroleum Corp. houses the pipe shop, welding shop, forge and blacksmith shop along with the maintenance tool room and warehouse, machine shop and numerous other crafts in one big building.

The very nature of pipefitting, welding and smithing operations are productive of considerable noise and, in a large building such as is considered here, the sound of hammering and handling steel may also result in resonance and echos which are as bad, or worse, than the original noise.

This was the case in the Cosden shop. Machinists in particular were frequently disturbed but complaints were common from the other, "quiet" shops, too. It wasn't practical to close in the offending areas and very desirable to have all the mechanical crafts housed in the one building.

The answer? The roof over the welding, pipefitting and smithy areas were soundproofed with insulating material, and strips running the length of these areas hung edgewise from the ceiling.

It still is just as noisy in these specific areas as before, but there are no more loud "crashes" and booming echoes bouncing around the rest of the building. The cost is an insignificant fraction of what it would have cost to build another building, or even partition off the offending noisemakers. Besides, the arrangement in no way interferes with air circulation for heating and ventilation.

Tar still, 10' diameter x 25' long, with corrugated fire tubes.
Struthers Wells
Stabilizer column, 6' 6" I.D. x 101' long. Furnished with platforms, rails, flanges and internals.

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 (To obtain more data on advertised products see page 1252)

CERAMIC BALLS for thermal pyrolysis and catalyst support beds

As a heat transfer and catalyst support medium in various refinery operations, "U.S." Ceramic Balls are proving unusually effective. They are being widely used in the field of pyrolysis and in catalytic reforming installations.

"U.S." Ceramic Balls possess heat-shock resistance, great crushing strength, superior thermal conductivity and high specific heat. The material is thoroughly vitrified, inert and is particularly recommended for its proven resistance to erosion and abrasion.

The smooth surface and spherical shape of "U.S." Ceramic Balls have proven more efficient than irregularly sized and shaped heat transfer elements. A special body ("CERATHERM-550") is available where exceptional thermal-shock and heat-resistance characteristics are required.

All sizes are available from 1/4" O.D. to 3" O.D.

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William Naden, director and vice-president of Esso Standard Oil Co., has been elected executive vice-president succeeding **Marion W. Boyer,** who was recently elected a director of Standard Oil Co. (N. J.).

Mr. Naden

Naden joined the company 28 years ago as a chemist in the Everett, Mass., refinery. From 1934 to 1944 he served successively as general superintendent of the Everett and Baltimore refineries. In 1946 he became the company's manager of employee relations and a director. He was appointed general manager of manufacturing in 1949 and elected a vice-president in 1950.

In Esso's Enjay Co. **Erving Arundale** and **Elfried Pennekamp** were appointed assistant directors of the newly opened Enjay Laboratories. Each will continue with his former responsibilities, Arundale as supervisor of chemicals and rubber activities, Pennekamp as head of chemical additives work.

Arundale began with Esso Standard Oil in 1937 as a student engineer, and worked from 1938 to the end of 1954 in chemical research. He was transferred to Enjay last January.

Pennekamp joined Esso Research and Engineering Co. in 1943 after receiving his master's in chemistry from the University of Tennessee. He became a section head in products research and was moved to Enjay in 1954.

T. J. Sullivan, formerly vice-president of manufacturing for Gulf Oil Corp., has been made a senior vice-president and will serve in that capacity on the newly formed management committee. Others elevated to senior vice-president and serving with Sullivan on the committee are **H. G. Meador,** formerly vice-president of domestic marketing; **W. L. Naylor,** formerly vice-president and comptroller; and **R. O. Rhoades,** formerly production vice-president.

Sullivan began with Gulf in 1921 as a foreman of the acid plant at the Port Arthur refinery. In 1930 he became assistant general superintendent at the refinery, and five years later was made general superintendent of all Texas refineries of the company. He was transferred to Pittsburgh in 1939 as assistant general manager of the manufacturing department and a year later made general manager.

Two new vice-presidents in the manufacturing department are **Bonner H. Barnes,** general manager of Gulf's refineries, and **Dr. Jerry McAfee,** vice-president and associate director of research in the Gulf Research and Development Co.

Barnes joined the company in 1921 as a chemist at the Port Arthur refinery. He was transferred to Sweetwater, Tex., as refinery superintendent in 1929 and to Toledo in the same capacity two years later. In 1935 he returned to Port Arthur as assistant general superintendent. Barnes was promoted to general superintendent of Gulf's manufacturing in Texas in 1939, resigning that in 1945 to serve with the Petroleum Administration for War as assistant director of refining. After the end of the war he returned to Gulf as assistant general manager of the company's manufacturing department in Pittsburgh, and four years later was appointed general manager of the refineries.

McAfee began with Gulf in 1945 at the Port Arthur refinery. In 1950 he

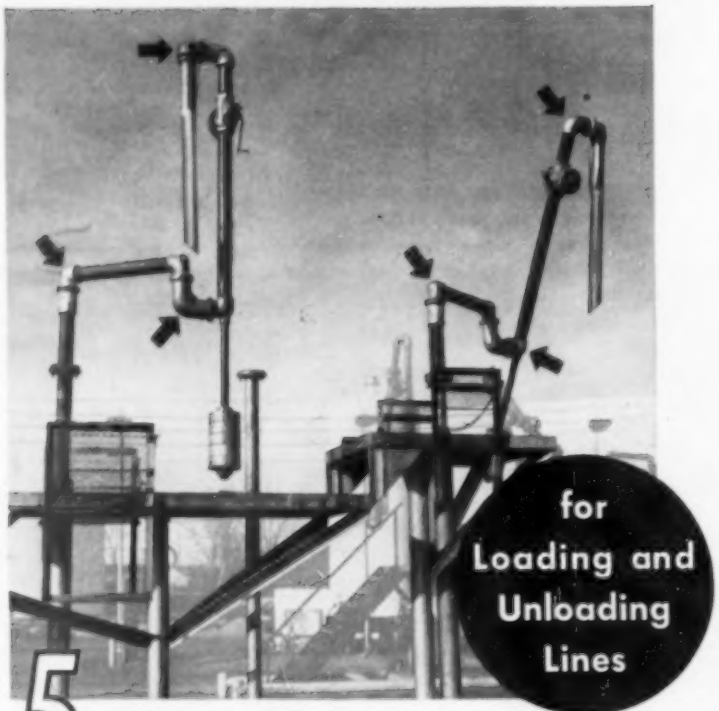
BAYONNE'S BILL RUDDY and his 35 mm. hobby

RECORDING cameraman of Esso Standard Oil Co.'s Bayonne refinery is Bill Ruddy, who is officially a clerk in the carpenter shop. Ruddy has been virtually a life-time victim of the photography bug. He began with still pictures in 1919 and succumbed to the fascination of movie-making in 1935, when he and his wife began taking annual auto trips around the country. He edits and titles his own film in a darkroom built in the cellar of his house.

Some years ago his skill with the camera came to the attention of Bayonne's management and he was asked to make some training movies and take some stills for the company magazine. About two years ago Bill began his biggest job: recording the highlights of a major construction program at the refinery. Whenever something new was to go up or something old to come down he would show up and take down the change with his camera. He "shot" the Porocel plant from the digging of the foundations to its completion. The old wax molds and the new molding machine are on his film, and there are many general views of the refinery's changing landscape.

Though his film history is still in progress, Bill had a showing of part of it at the refinery's recent Wax Fair, when visitors were shown the new wax-making facilities. "The Changing Scene," as it was called, was shown in the interior of a large storage tank —dubbed "Cinematank"—which was about to come down.

BARCO Swing Joints and Assemblies



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3. **CONTROLLED TORQUE**—No annoying, uncontrolled swinging of lines. They swing easily but stay put.
4. **LONG LIFE**—New "Bar-Moly" dry lubricant process gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.
5. **EASY MAINTENANCE**—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field. Frequent greasing not required to maintain sealing.

The Barco line is complete with single swing, double swing, and counter-balance styles and assemblies to meet every need. Sizes 1", 1½", 2", 2½", 3", 4". All steel or malleable iron. Send for latest Catalog No. 400 containing engineering and ordering information. *Worldwide sales and service.*

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Barrington, Illinois

was transferred to the research subsidiary and appointed director of the chemistry division. The following year he became assistant director of research, responsible for all product and process work at the laboratory, and in 1954 was made an associate director and elected a vice-president.

John W. Nixon has been appointed plant manager of the Tuscola, Ill., facility of National Petro-Chemicals Corp. He has been chief engineer at the plant since 1952, when he was first employed by the firm.

Mr. Nixon

Charles D. Carnes has been promoted from assistant to chief engineer. **George A. Siegelman** has been moved from plant superintendent to assistant plant manager, and **Clifford E. Oman** from area superintendent of the alcohol plant to assistant plant superintendent.

The former area superintendent of ethyl chloride, **Robert E. Jones, Jr.**, has been transferred to the same job in alcohol and ethyl chloride processes.

The firm is a joint enterprise of National Distillers Products Corp. and Panhandle Eastern Pipeline Corp.

Russell L. Bauer has been appointed process engineering supervisor of Mobay Chemical Co.'s engineering department. Bauer was a development manager in the development department of Monsanto Chemical Co.'s organic chemicals division. He first joined Monsanto in 1937. Monsanto is part-owner of the Mobay firm.

L. R. Strawn has been appointed manager of the Jefferson Chemical Co.'s manufacturing division. **M. H. Holmes** has become manager of the Port Neches, Texas, plant, and **Robert H. Darling** has been made chief engineer of the company, with headquarters at Port Neches.

Darling's post was created recently and gives him responsibility for the work of the entire engineering branch, including process engineering, construction, utility distribution, maintenance and laboratory analysis.

B. Brewster Jennings, president of Socony Mobil Oil Co. since 1944, has been elected chairman of the board of directors, succeeding **George V.**

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BETZ

CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

(To obtain more data on advertised products see page 1252)

how a Texas refinery saved $1200, reduced tower down-time over 25% with amazing Oakite

RUSTRIPPER

The last time this Texas refinery had cleaned its 28-tray oil absorber tower, it took 24 hours — and every hour of down-time cost the refinery $100.00.

The superintendent gave Oakite RUSTRIPPER a try. After rinsing the tower with steam and hot water for two hours, a pre-mixed solution of Oakite RUSTRIPPER was pumped into the tower, recirculated and agitated for ten hours at 210 degrees. Then it was routed through the mist extractor for an additional three hours and drained. A three-hour circulating water rinse completed the cleaning cycle.

Results? Oakite RUSTRIPPER did a job that was 95% perfect. Down-time was reduced by six hours -- and cleaning costs slashed by $1200.

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Personals

Holton, who has retired. **Albert L. Nickerson,** vice-president and director in charge of foreign trade, has been chosen president, and **Austin T. Foster** and **Paul V. Keyser, Jr.,** were elected directors.

Jennings, who has been a director of Socony Mobil since 1939, will remain its chief executive officer because he has retained his position as chairman of the executive committee. He has been in the company since 1920, after his graduation from Yale University.

Nickerson has worked with Socony's domestic and foreign marketing activities since he began with the company as a service station attendant in 1933, after his graduation from Harvard.

Foster, general counsel, continues with that portfolio as a member of the board, and Keyser becomes a vice-president and director in charge of foreign trade, succeeding Nickerson.

In Socony's operations, **Frank V. Williams,** who was manager of the refinery at Olean, N.Y., has been appointed assistant manager of the lubrication and special products department. Williams joined Socony in 1935 at the Paulsboro, N.J., refinery, where he remained until he was transferred to Olean in 1945.

R. L. Argus, formerly superintendent of construction and maintenance at the Destrehan, La., refinery of Pan-Am Southern Corp., has been appointed assistant manager of the refinery. He has been with Pan-Am for 22 years, starting as a laboratory sampler. He holds a bachelor's degree from Tulane University.

John M. Brown, assistant manager-operations of the El Dorado, Ark., refinery, has been promoted to assistant manager of the refinery. Brown began with Pan-Am in 1925 as a stillman. In 1929 he became assistant superintendent of the El Dorado refinery and in 1951 assistant manager-operations.

James W. Foley has been elected executive vice-president of The Texas Co. He became a vice-president in 1953 and a director in 1954. He is also a director of a number of exploration and foreign producing companies. Foley joined Texaco in 1932 and has been associated with the company's producing activities since then.

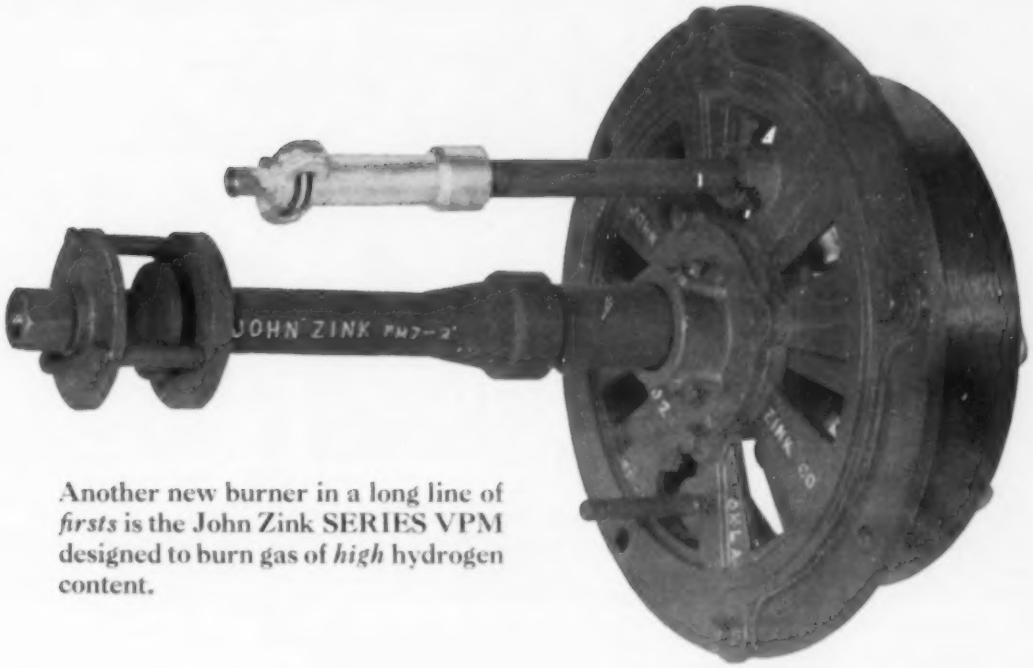
Ray Powell has been named assistant to the senior vice-president of Texaco. He has been supervisor of process engineering in the refining department since 1944. Powell joined the company in 1931 and has served

JOHN ZINK

JZ

VPM BURNER

with the John Zink ST pilot



Another new burner in a long line of *firsts* is the John Zink SERIES VPM designed to burn gas of *high* hydrogen content.

Burns with a short and crisp flame with primary air door open. The new high efficiency aspirator on the SERIES VPM burner makes it possible to switch from a *high* hydrogen gas fuel to natural gas.

Capacities from 500,000 Btu/hr to 12,000,000 Btu/hr.

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Thermal insulation on outdoor operating facilities needs a "raincoat." This material depends upon small air spaces formed by the flake fibers, or spheres of solids in the insulation itself to retard the flow of heat (or cold). Should moisture fill all or part of these air spaces the efficiency of the insulation would be seriously affected.

Weathercoat gives lasting protection. Weathercoat has an extremely high resistance to moisture in all its forms. (It has a Perm rating of 0.0175 for 0.10" thick dry film.) It is a factory compound of asphalt emulsion and mineral fillers and fibers that sets to a smooth, tough and pliable finish. Because no clays or other hydrophilic fillers are used in Weathercoat, it stays "alive." This assures long-lasting protection for insulated surfaces.

Nation-wide acceptance. Many of the largest refineries, chemical plants, and power stations in the nation are regular users of Weathercoat, both for maintenance and for new construction. During the last year alone, over 5 million sq. ft. of insulation have been coated with Weathercoat. The Laykold Engineer in our office nearest you will supply full details.

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Inglewood, Calif. Oakland 1, Calif.
Portland 7, Ore. Washington 5, D.C.
San Juan 23, P.R.

in a number of the company's refineries and terminals, in addition to the New York City headquarters of the refining department.

Harry Levin, formerly supervisor of the analytical and testing department at Beacon Laboratories, has been made assistant to the manager of the research division at the laboratories.

Levin has been succeeded by **F. M. Roberts,** who was assistant supervisor of the department.

William C. Soudriette and **Harold W. Torgeson** have been appointed staff assistants to the manager of Cities Service Oil Co.'s refining division. Soudriette works primarily in refinery operations and research, Torgeson with lubricants manufacture and application.

Soudriette joined Cities Service in 1947 at the East Chicago, Ind., refinery as an engineer. He served as process engineer, catalytic cracking foreman and, in 1953, was named assistant cracking foreman at the refinery.

Torgeson began with the company in its junior engineer training school in 1947. His first assignment was at the Ponca City, Okla., refinery. In 1949 he was transferred to Bartlesville to supervise the company's lubricating oil and grease operations.

Philip A. Nolan has been named chief chemist for Great Northern Oil Co. at the Pine Bend, Minn., refinery. He moves to Great Northern from the Farmers Union Central Exchange refinery at Laurel, Mont., where he was chemical engineer in charge of transfer and storage operations.

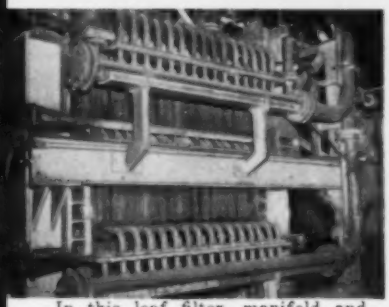
The Pine Bend refinery is scheduled to go on stream in August.

Dr. William H. Bowman has been appointed assistant general manager of the organic chemicals division of the American Cyanamid Co. Bowman has been with Jefferson Chemical Co., an American Cyanamid affiliate, for the past 10 years.

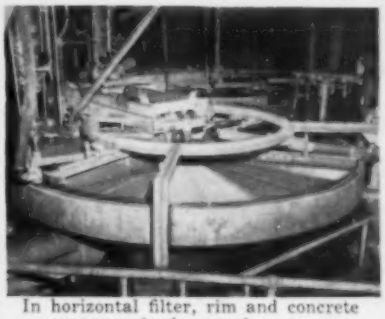
Bowman received his B.A. Sc. in chemical engineering from the University of Toronto, his Sc. M. in chemistry from New York University two years later, in 1934. He then returned to Toronto, where he took a master's in chemical engineering and a doctor's in industrial chemistry.

James R. Arrington has succeeded **G. D. Priestman** as manager of the economics department of the Carter Oil Co. Priestman will accept a job with Standard Oil Co. (N.J.) Arrington began with Carter in 1937, fol-

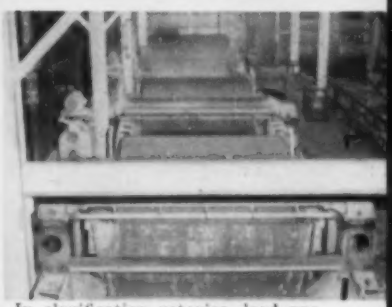
"We rely on lead at every stage of acid handling" says large chemical processor



In this leaf filter, manifold and plates are lead

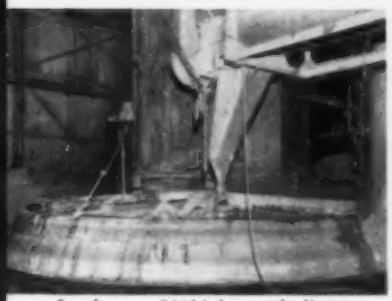


In horizontal filter, rim and concrete supports are lead-covered



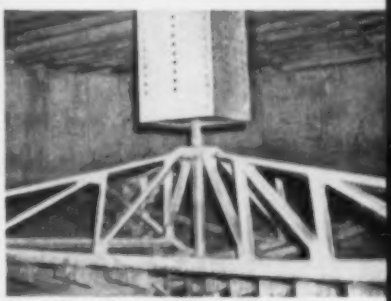
In clarification rotaries, lead protects parts exposed to acid

"...in our filters



Lead apron 24" high guards digester rim against spill

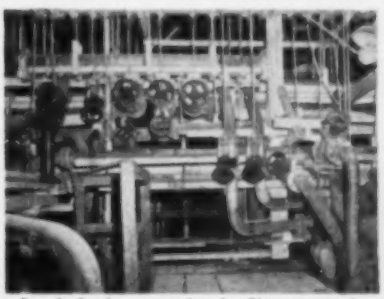
Lead lining protects interior of this steel digest tank



Lead lines this concrete settling tank, covers rake. Plows are solid lead

"...in our tanks

Lead-lined valves and piping serve digesters



Lead checks corrosion in filter control valve station

Lead stacks and flues withstand corrosive fumes.

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National Lead is a leading supplier of lead equipment for handling sulphuric acid solutions. If you have an acid control problem, we will be glad to help you solve it.

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"Alamask" CASE HISTORY

A well-known oil refinery had an injunction to stop operations of its catalytic cracking unit, due to odors emanating from spills, separators and other wastes, stack fumes and products of combustion. RHODIA was consulted and ALAMASK used. Here is an excerpt from a letter from the refinery:

"Very effective masking of odors resulted and in view of our actions all cases against us were withdrawn. We are very grateful to RHODIA for what they have done for us and are happy to pass on our experiences to others in similar difficulty."

If odors from your refinery are contaminating the community, RHODIA can help you, too. Our experienced odor engineers will be happy to consult with you on your malodor problems.

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lowing his graduation from the University of Tulsa with a B.S. in chemical engineering. He worked as a petroleum and research engineer for the company until 1951, when he became chief economist. Two years later he was appointed assistant manager of the economics department.

Samuel Lenher, assistant general manager of Du Pont Co.'s organic chemicals department, has been elected a director, vice-president, and a member of the executive committee of the company.

Starting as a research chemist in 1929, Lenher became successively technical adviser to the fine chemicals division and superintendent of the development group at the Chambers Works, Deepwater Point, N.J. In 1944 he was named assistant manager of the Chambers Works and the next year, manager.

He was transferred to Wilmington headquarters as director of manufacture for the dyestuffs division in 1946. In 1950 he became assistant general manager of organic chemicals.

Lenher is currently president of the Synthetic Organic Chemical Manufacturers Association.

Neil H. McKay has been made the chief technologist of the Martinez, Calif., plant of Shell Chemical Co. He replaces **M. L. Sagenkahn,** who was transferred to the company's Torrance, Calif., plant.

McKay was senior technologist at the Houston chemical plant before his latest move. He began with Shell in 1942 as a chemist at the Dominguez plant.

R. H. Dourson, former manager of the experimental laboratory of Shell Oil Co.'s Wood River, Ill., refinery, has succeeded **B. W. Dunbar** as manager of catalytic cracking. Dunbar was transferred to Shell's new Anacortes, Wash., refinery. Dourson joined the company in 1941.

New manager of the experimental laboratory is **R. W. Lewis,** who was the group leader in charge of lubricating oil research and special products at the laboratory. He joined the company in 1943 as a research chemist at Wood River.

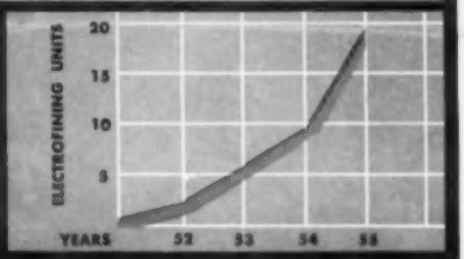
D. C. Hauseh has been transferred to Anacortes as a special technologist to help put the new refinery on stream. At Wood River Hausch worked in the same capacity on refinery distillation problems. He has been with Shell since 1933, when he began as a laboratory technician at the Wilmington, Calif., refinery.

WHY THE ACCELERATING INTEREST IN

ELECTROFINING

In 1950 the first Petreco Electrofining* Unit was installed. Now there are 18 Electrofiners installed and — at the last count — six more under construction and on order.

**Petreco Electrofining is a compact, automatic, fast treating process for continuously contacting a light hydrocarbon stream with a treating agent, then rapidly separating the chemical from the treated product.*



THIS TABLE SHOWS THE WIDE ACCEPTANCE AND APPLICABILITY OF *ELECTROFINING*.

ELECTROFINING INSTALLATIONS

Refinery Location	Electrofining Treatment	Number of Units	BPD Capacity	Stock Treated
California	Acid	1	16,000	Light Pressure Distillate
California	Acid	4	8,600	Lube and Spray Oils
Indiana	Caustic	1	10,000	Blended light cycle oil and straight run naphtha
Kansas	Doctor	1	11,000	Straight run and cracked gasoline
Pennsylvania	Caustic**	1	12,500	Gasoline
Pennsylvania	Caustic**	1	3,600	Gasoline
Texas	Caustic**	2	5,000	Thermally cracked distillate
Texas	Caustic**	2	5,000	Cat distillate
Texas	Caustic**	3	30,000	Cat distillate
Texas	Acid	1	4,430	Lube Oil
Texas	Sulfonation	1	2,000	Virgin distillate
Texas	Dewatering	2	6,000	Vacuum Tower Gas Oil

**Caustic Scrub and Water Wash

Additional Electrofiners are under construction or on order for refiners in Canada, Pennsylvania, New York, Ohio, and New Jersey.

HERE ARE THE REASONS WHY MORE AND MORE REFINERS ARE SPECIFYING ELECTROFINING FOR LIGHT OIL TREATING:

1. Compact
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6. Eliminates Haze Stabilizers
7. Fast-Tower to Market
8. Efficient—Removes Tarry Acids, Spent Caustic, Metals, Mercaptans and other Impurities
9. Flexible—Single, Dual, Two Phase Units Available
10. Automatic—Minimum Operating Attention Required
11. Costs Less than any Comparable Process

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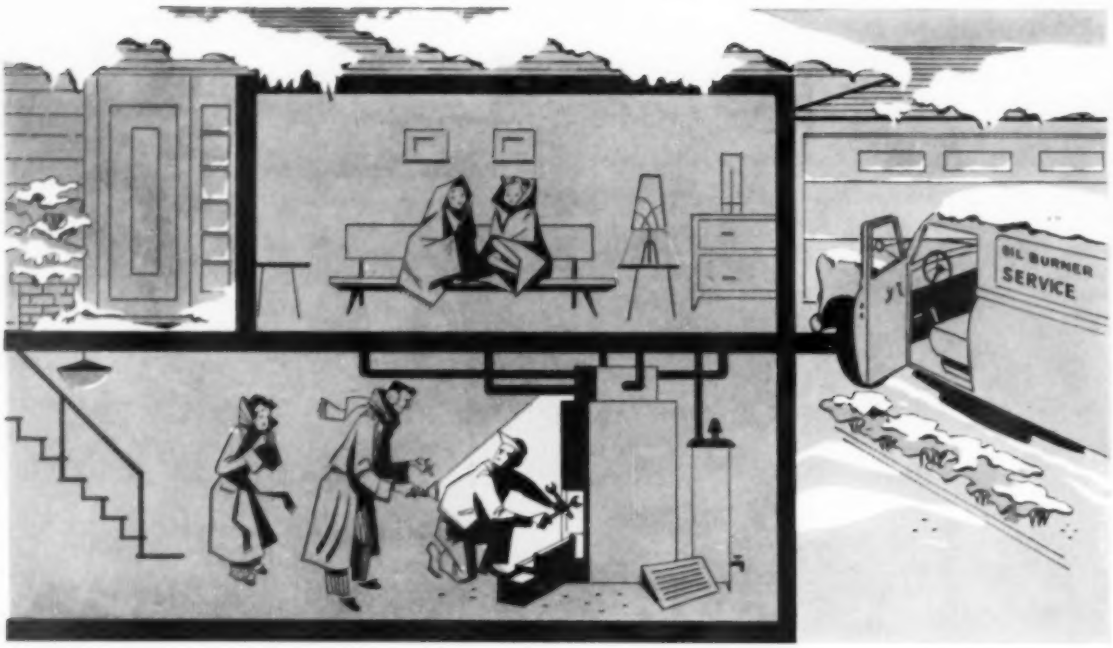

Oil burner ignition failures can be curbed with this ASHLESS heating oil additive

YOU CAN now use a *single additive* to do *two important jobs.*

As a stabilizer and dispersant, Du Pont Fuel Oil Additive No. 2 does a highly efficient job of preventing sludge formations that cause filter fouling and nozzle plugging.

IN ADDITION, it offers an important plus value by minimizing ignition failures. How?

Being a nonmetallic *ashless* additive, it does not leave a metallic ash deposit which can foul the operation of the electrical system. Thus, it helps to eliminate many of the service calls that cost your distributors time and money . . . and even loss of business through customer dissatisfaction.

Many other advantages

Added to freshly prepared stocks at the refinery, FOA-2 retards the formation of insoluble residues during storage . . . keeps oil free flowing and clean burning. Too, it reduces the particle size of any residues that are formed . . . helps clean out sludge deposits that clog burner filters, screens and nozzles.

Holds customers

Du Pont FOA-2 can help you stimulate consumer preference for oil heat. It reduces need for service—helps provide clean, economical heat. It helps your distributors curb costly, sludge-caused service calls. And it has no harmful side effects.

Refining flexibility

With this stabilizer-dispersant you can blend cat-cracked and straight-run products to gain manufacturing flexibility for varying seasonal demands. You can also use it to upgrade stocks for increase of yield of domestic heating oils. In this way, you can release straight-run stocks for premium diesel fuel or catalytic-cracking charge stock. FOA-2 is effective in diesel fuels, too, for relieving filter-plugging and injector-sticking problems.

Because it is effective in small concentrations, FOA-2 is economical. To find out how much it can do for you and exactly how little it costs, contact your Du Pont Petroleum Chemicals Division representative or regional office.

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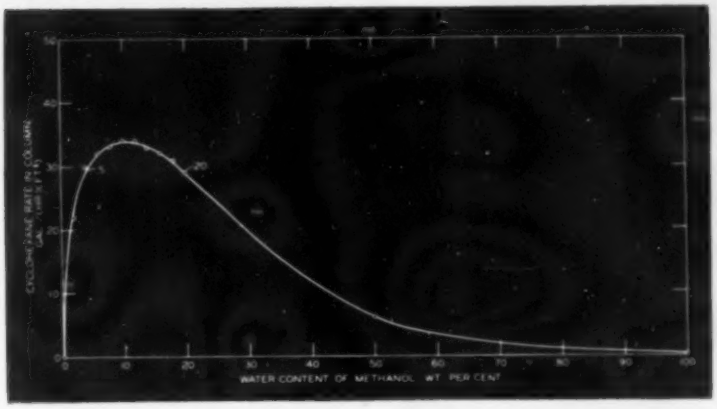
By Peter J. Gaylor, Patent Attorney, Elizabeth, N. J.



WATER IN METHANOL SOLVENT will speed the extraction of cyclohexane from admixture with n-heptane

Water in Methanol Solvent Gives Better Hydrocarbon Extraction

METHANOL containing a controlled quantity of water is recommended as the extraction solvent in the separation of naphthenic from paraffinic hydrocarbons, in the Phillips Petroleum Co. patent No. 2,695,322. The film thickness of a low viscosity solvent is less than that of a high viscosity solvent. Accordingly, diffusion rates are claimed to be higher and increased extraction is obtained.

It is advantageous to use as high a percentage of water as possible in methyl alcohol in order to increase the density difference between the alcohol-water solution and the raffinate phase. This expedites the rising or settling rate of the raffinate. However, the amount of water which can be used is limited by its effect on the solubility of one or more of the hydrocarbons being treated. A further advantage is that only a very small quantity of methanol is carried out with the raffinate phase, say 0.04-0.05%, at ordinary temperatures in n-heptane, and this may be recovered by washing with water, if desired.

The illustration depicts a curve showing the relationship between the capacity of an extraction column of unit cross section and the water content of the extraction solvent. It will be observed that a water concentration of 5-20%, based on the weight of the methyl alcohol, gives the highest extraction capacity for removing cyclohexane from n-heptane.

React Water and Olefins To Produce Ketones

OLEFINIC hydrocarbons can be reacted with water, according to the Shell Development Co. patent No. 2,635,119, to produce good yields of the corresponding ketones. The reaction is conducted at 200°-500° C. and pressures of 150-2000 psi. in the presence of at least one sulfide of molybdenum, tungsten, tellurium or selenium. In the preferred practice, there is also employed not over 40 mole percent (based on total catalyst) of a sulfide of iron, cobalt or nickel. A particularly desirable catalyst of this type is a mixture of tungsten sulfide and nickel sulfide.

The olefins preferred for the reaction are the aliphatic chains of at least three carbon atoms, between two of which there exists an aliphatic double bond. Examples include 1-pentene, propylenes, 2-butene, 2-hexene, 1-octene, 1 dodecene, 4-0-tolyl-1-butene, 1, 6-diphenyl-3-hexene.

The data shown in the table were obtained in reacting a vaporous mixture of olefin and water, using a tungsten sulfide-nickel sulfide catalyst at 500 psi. and 305° C.

Ketone Production by Reaction of Olefins With Water

Olefin	Mole Ratio, H_2O/Olefin	Space Velocity (g. hydrocarbon/hr./l of Cat.)	Olefin Conversion	Ketone Yield
1-octene	4.9	823	34	42
1-pentene	5.3	400	42	40
2-pentene	3.6	565	38	32
mixed C_6 olefins[1]	5.7	520	34	14
mixed C_7 olefins[2]	4.8	590q	16	40

[1] Obtained by dimerization of propylene.
[2] Obtained by cracking of paraffin wax.

Sulfurized Products

A METHOD for producing viscous oil-soluble sulfurized products through reaction of unsaturated organic compounds with an ammonium hydrosulfide-hydrogen sulfide reactant is described in the Shell Development Co. patent No. 2,654,733.

In this process, isopropyl alcohol is saturated with dry ammonia and then with dry H_2S. To this mixture is added the unsaturated organic material such as isophorone, stilbene, cracked wax, oleic acid, rapeseed oil, ethyl cinnamate, ammonium undecylenate, tall oil, cinnamaldehyde, cottonseed oil, etc. The material is allowed to stand at room temperature, and good yields of sulfurized product are obtained.

In the case of isophorone (1,1,3-trimethyl cyclohexene-3-one-5), a viscous, dark brown liquid containing 26.4% sulfur was obtained.

Patents Issued in June

The following classified listing gives the patent number, patentee, or assignee, and a brief description of all patents believed to be of interest to the petroleum processing industries, as contained in the Official Gazette of the U.S. Patent Office for June 7, 14, 21, and 28, 1955, Vol. 695, Nos. 1-4.

PROCESSES

Refining

Re 24,025 (Esso Research & Engineering Co.) Deasphalting operation for residual oils using naphtha solvent.
2,709,496 (Socony Mobil Oil Co., Inc.) Gas drier.
2,709,641 (Universal Oil Products Co.) Extrac-

No. 4* of . . .

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Patents

tion column employing spray nozzles over trays.
2,709,643 (Shell Development Co.) Contacting liquids with solids, using fixed bed.
2,709,674 (Socony Mobil Oil Co., Inc.) Drying of adsorbent granular solids.
2,709,678 (Phillips Petroleum Co.) Distillation control system.
2,710,278 (Phillips Petroleum Co.) Method of supplying a sponge absorption medium to a fractionating absorber.
2,710,668 (Esso Research & Engineering Co.) Adsorption process for separating gaseous hydrocarbons.
2,710,790 (Esso Research & Engineering Co.) Liquid-liquid contacting apparatus.
2,710,855 (British Petroleum Co. Ltd.) Extractive crystallization of mineral oils by means of urea.
2,711,433 (Dow Chemical Co.) Process for extraction and recovery of aromatic hydrocarbons from hydrocarbon mixtures (use of low-boiling azeotropes).

Conversions

2,709,642 (Esso Research & Engineering Co.) Chemical reactor for polymerization.
2,709,673 (Union Oil Co. of Calif.) Process and apparatus for solids conveyance in the conversion of hydrocarbons.
2,709,675 (Pittsburgh Consolidation Coal Co.) Treatment of agglomerative carbonaceous solids by destructive distillation.
2,709,676 (Esso Research & Engineering Co.) Production of marketable pelletized coke agglomerates from heavy oils.
2,710,279 (Gulf Oil Corp.) Method for conducting several fluidized catalytic hydrocarbon conversions in a single reactor.
2,710,280 (F. L. Smidth & Co.) Method and apparatus for expelling volatile constituents from solid carbonaceous fuel.
2,710,826 (Esso Research & Engineering Co.) Method for hydroforming naphthas, using Mo oxide catalyst.
2,710,827 (Esso Research & Engineering Co.) Fluid hydroforming process.
2,710,828 (California Research Corp.) Vertical shale retorting with intermediate oil recovery.
2,710,854 (Standard Oil Co.-Ind.) Ethylene polymerization with catalyst composed of a group VIa metal oxide and an alkaline earth carbide.
2,711,350 (Houdry Process Corp.) Lift for elevating granular solids.
2,711,385 (Fluor Corp., Ltd.) Catalytic reforming heat recovery and product separation.
2,711,386 (Houdry Process Corp.) Gas lift operation in a moving bed conversion of hydrocarbons.
2,711,387 (Esso Research & Engineering Co.) Treating subdivided solids to form highly turbolent dense mass of solids.
2,711,420 (Dow Chemical Co.) Production of aromatic hydrocarbons by reacting CO and hydrogen in presence of Gp. VIII catalyst.

PRODUCTS

Chemicals

2,709,639 (Food Machinery & Chemical Corp.) Process for the manufacture of carbon disulfide from low boiling hydrocarbons and superheated sulfur.
2,709,662 (Esso Research & Engineering Co.) Accelerated process for bodying vegetable drying oils by heating with synthetic drying oil.
2,709,684-7 (California Research Corp.) Detergent composition containing caking preventive.
2,709,690 (Shell Development Co.) Epoxy resins esterified with drying oil fatty acids and phosphoric acid.
2,709,695 (Pan American Refining Corp.) High-temperature polymerization of unsaturated hydrocarbon mixtures to resins.
2,709,714 (Esso Research & Engineering Co.) Production of oxo alcohols.
2,709,715 (Phillips Petroleum Co.) Sulfenyl halide-polymer addition products and their preparation.
2,710,300 (Gulf Research & Development Co.) Dithiol adipates.
2,710,301 (Shell Development Co.) Phosphorous esters and a process for the preparation of the same.
2,710,797 (Gulf Research & Development Co.) Process for removing cobalt carbonyl, etc. from hydroformylation products by thermal decomposition.
2,710,829 (Stanolind Oil and Gas Co.) Separation of oxygenated compounds from aqueous solutions.
2,710,831 (Stanolind Oil and Gas Co.) Process for stripping soap solutions containing oil-soluble chemicals.
2,710,872 (Universal Oil Products Co.) Production of esters of dithiocarbamic acid.
2,710,879 (Hercules Powder Co.) Synthesis of carboxylic acids by addition of CO to alcohols, etc.
2,711,388 (Esso Research & Engineering Co.) Concentration of aqueous acids by flash distillation.
2,711,403 (Shell Development Co.) Esters of aromatic olefinic phosphinic acids.
2,711,429 (Imperial Chemical Industries Ltd.)

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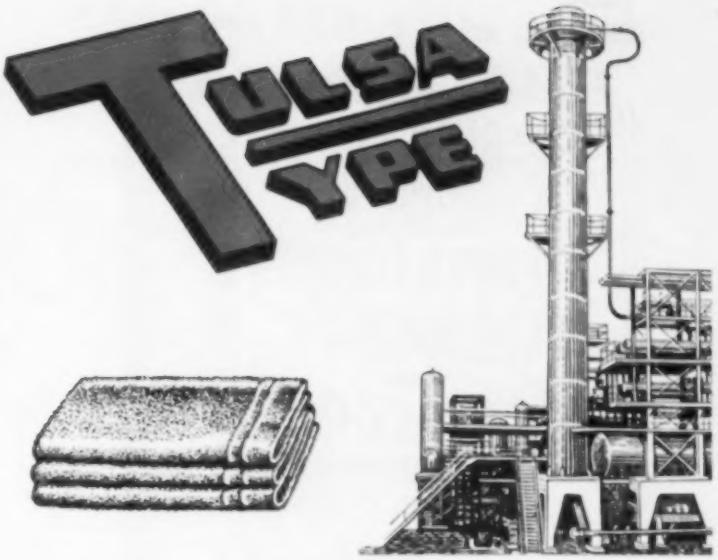

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New York 36, N. Y.

Note: New York City residents add 3% Sales Tax

(To obtain more data on advertised products see page 1252)

NO.2 in a series of ALUMICOAT APPLICATIONS

RESISTS HIGH TEMPERATURE CORROSION!

Alumicoat

Molten Aluminum

PROCESS PROTECTS REFINERY EQUIPMENT

More and more refineries are discovering the advantages of the new ALUMICOAT Process! ALUMICOAT offers a firm resistance against corrosive media — *especially sulphur compounds* — and extreme temperatures!

In the ALUMICOAT Process, refinery parts are dipped in molten aluminum to produce a metallurgical iron-aluminum bond at the interface and a surface overlay of pure aluminum. At temperatures exceeding the melting point of aluminum, the aluminum on the surface diffuses. This diffused coating, together with the iron-aluminum bond, provides a refractory material that gives steel maximum protection against high temperature scaling.

The Alumicoat Process can solve your corrosion and oxidation problems. Send for full details today!

ARTHUR TICKLE ENGINEERING WORKS, INC.

24 Delevan Street MAin 5-4200 Brooklyn, N. Y.

Patents

Method and apparatus for controlling temperature in olefin carbonylation.

Fuels

2,709,646 (United Engineers & Constructors Inc.) Method for producing oil gas by pyrolysis.
2,710,251 (Standard Oil Co.-Ohio) Motor fuel containing an alkyl boronic acid.
2,710,252 (Standard Oil Co.-Ohio) Alkanediol esters of alkyl boronic acids and motor fuel containing same.
2,711,419 (Surface Combustion Corp.) Process and apparatus for making fuel gas containing CO (using Ni catalyst).

Lubricants

2,709,682 (The Texas Co.) Lubricant containing reaction products of conjugated unsaturated ketones with organic sulfhydryl compounds.
2,710,282 (Standard Oil Co.-Ind.) Hydrocarbon oil compositions containing tripolymer pour point improving materials.
2,710,283 (Standard Oil Co.-Ind.) Oil compositions containing tripolymer V.I. improvers.
2,710,103 (Phillips Petroleum Co.) Recovery of guanidine petroleum sulfonates as oil detergents.
2,710,817 (Gulf Research & Development Co.) Lubricating compositions containing soap and bentonite compound.
2,710,818 (Esso Research & Engineering Co.) Thixotropic lubricating grease containing polycarboxylic acid soap.
2,710,839-40 (Standard Oil Co.-Ind.) Aryl-urea thickened greases.
2,710,841 (Standard Oil Co.-Ind.) Method of preparing substituted urea-thickened greases.
2,710,842 (The Texas Co.) Hydraulic transmission fluid containing methacrylate ester copolymer, sulfurized sperm oil, etc.
2,710,877 (Esso Research & Engineering Co.) Synthetic lubricating composition containing complex ester having chlorine and fluorine.
2,711,393 (Standard Oil Co.-Ohio) Thickened lubricants using inorganic gelling agent and imidazoline.
2,711,394 (Standard Oil Co.-Ohio) Inorganic gel-thickened graphite forge die lubricant.
2,711,395 (Sinclair Refining Co.) Cutting oil composition containing basic barium mahogany sulfonate and S-Cl pinene.
2,711,396 (Sinclair Refining Co.) Cutting oil composition containing S-Cl mineral oil inhibited with basic barium mahogany sulfonate.

Specialties

2,709,278 (J. W. Greer Co.) Method of moulding wax.
2,710,272 (United States Steel Corp.) Tin pot oil composition containing 5% fatty oil, over 0.25% stannous chloride, balance mineral oil of over 500° F. fl. pt.
2,710,794 (Shell Development Co.) Defoliation of growing plants with N-nitroso N-methyl urea.
2,711,360 (Shell Development Co.) Vapor-phase corrosion inhibition with a mixture of inhibitors (hydrocarbon ammonium nitrite salt and amin carboxylate).
2,711,374 (Esso Research & Engineering Co.) Corrosion inhibiting composition (dibasic acid ester, oil soluble petroleum sulfonate, lecithin and alkyl cresol).
2,711,378 (Socony Mobil Oil Co., Inc.) Emulsion of wax for imparting water repellency to fibrous materials.
2,711,399 (General Electric Co.) Silicone rubber with preaged carbon black.

Miscellaneous

2,709,365 (Phillips Petroleum Co.) Flowmeter.
2,709,539 (Phillips Petroleum Co.) Container-filling apparatus.
2,709,645 (Esso Research & Engineering Co.) Production of carbon monoxide and hydrogen from gaseous hydrocarbons.
2,709,688 (Allied Chemical & Dye Corp.) Treatment of aluminum fluoride or zirconium fluoride catalysts with chlorine trifluoride.
2,709,713 (Esso Research & Engineering Co.) Iron removal from aldehyde synthesis process.
2,710,541 (The Texas Co.) Apparatus for volume measurement.
2,710,624 (Sun Oil Co.) Pressure operated actuating mechanism.
2,710,625 (Sun Oil Co.) Pressure responsive actuated valves.
2,710,666 (H_2 Oil Engineering Corp.) Gas line safety shut-off device.
2,710,799 (Universal Polychem Co.) Recovery of platinum from alumina base platinum catalyst.
2,711,368 (Esso Research & Engineering Co.) Process for reducing oxidic iron ore in fluidized zone.

EQUIPMENT

Processing, general

2,710,016 (Service Engineering) Fluid-blending apparatus.

(To obtain more data on advertised products see page 1252)

2,710,071 (Black, Sivalls & Bryson) Horizontal separator for mixed fluids.
2,710,175 (Burgess-Manning Co.) Heat exchange panel structure.
2,710,177 (C. F. Braun & Co.) Bubble-cap assembly and choke.
2,710,250 (Colgate-Palmolive Co.) Apparatus for continuous liquid-liquid solvent extraction of inorganic salt impurities from organic salt solutions.
2,710,280 (F. L. Smidth & Co.) Apparatus for expelling volatile constituents from solid carbonaceous fuel.
2,710,663 (U.S. Steel Corp.) Apparatus for removing naphthalene from coke oven gas.
2,710,790 (Esso Research and Engineering Co.) Liquid-liquid contacting appiratus.
2,711,214 (The Lummus Co.) Burner for heavy fuels.
2,711,226 (Research Corp.) Electrified centrifugal gas-cleaning device.
2,711,307 (Shell Development Co.) Contacting tray construction.
2,711,308 (Shell Development Co.) Grid tray contact column.
2,711,419 (Surface Combustion Corp.) Apparatus for making fuel gas.
2,711,750 (Austin S. Norcross) Apparatus for controlling the viscosity of a processing liquid.
2,711,826 (National Tank Co.) Low-temperature separating units.
2,711,833 (Gulf Research and Development Co.) Extractor for particulate material.
2,711,881 (Ernest A. Rose) Heat exchanger.

Catalytic Reactors

2,711,350 (Houdry Process Corp.) Lift for elevating granular solids.

Instruments

2,709,914 (Pillsbury Mills) Apparatus for determining the moisture content of materials.
2,709,918 (Sun Oil Co.) Tank gage.
2,710,015 (Hagan Corp.) Pressure differential response devices of hollow ring type, provided with means for converting response into pressure outputs.
2,710,537 (Secretary of the Army) Calibration stand for flow meters.
2,710,538 (U.S. Atomic Energy Commission) Electromagnetic pressure gage.
2,710,539 (Martin Pollack) Surface tension meter.
2,710,541 (The Texas Co.) Apparatus for volume measurement.
2,711,465 (American Cyanamid Co.) Liquid level control.
2,711,752 (Union Oil Co. of Calif.) Fluid flow control systems.

Pumps & Compressors

2,709,965 (David P. Litzenberg) Motor driven pump.
2,710,136 (Kaiser Metal Products) Axial flow compressor.
2,710,137 (Maurice Arnouil) Compressor.
2,710,205 (Ingersoll-Rand Co.) Sealing device for rotary pump shafts.
2,710,206 (New York Air Brake Co.) Running seal for rotary shaft.
2,710,581 (New York Air Brake Co.) Rotary pump.
2,711,085 (Air Products Inc.) Apparatus for pumping volatile liquids.
2,711,137 (Clifford B. Moller) Chemical feed pump.
2,711,284 (Marshall W. Phillips) Vacuum pump.
2,711,285 (Lau Blower Co.) Blower.
2,711,332 (Pierre Audemar) Fluid seal.
2,711,697 (Lloyd T. Gibbs) Variable capacity pump.

Valves & Fittings

Re 24,019 (Allis Chalmers Mfg. Co.) Pipe joint.
2,710,014 (Black, Sivalls & Bryson) Pressure release apparatus.
2,710,017 (Dorseal Co.) Valve.
2,710,020 (Manville Mfg. Corp.) Fluid control valve.
2,710,021 (Henry Valve Co.) Non-chatter check valve.
2,710,023 (Durabla Mfg. Co.) Check unit or valve.
2,710,027 (Helmut E. Hoogen and Raymond R. J. Daniels) Tube closures.
2,710,121 (Socony Mobil Oil Co.) Reciprocating disk valve.
2,710,162 (Max E. Snoddy) Pressure responsive diaphragm operated valve.
2,710,624 (Sun Oil Co.) Pressure operated actuating mechanism.
2,711,266 (American Locomotive Co.) High-pressure closures.
2,711,302 (South Houston Machine Co.) Controlling valve assembly.
2,711,753 (Dresser Industries) Temporary by-pass for pipe lines.
2,711,754 (Alfred McKinney) Fluid operated control apparatus.
2,711,877 (Ohio Injector Co.) Gate valves.

are chemicals

EATING UP

your packing dollars?

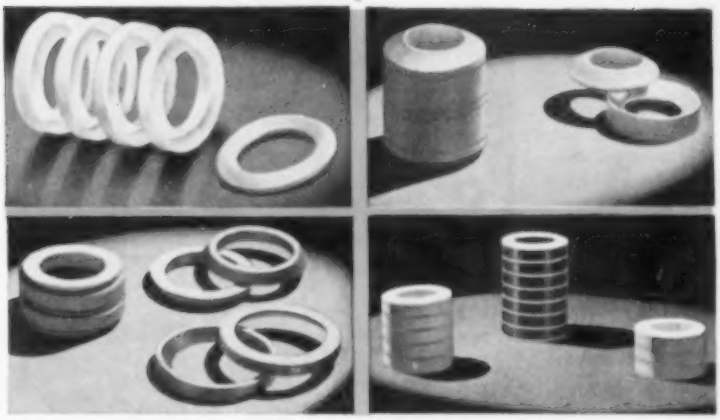
Get Chemiseal Packings that last months instead of hours. Packings that won't deteriorate, won't contaminate, won't "freeze" shaft action because they are made of TEFLON —impervious to practically all chemicals.

V-TYPE PACKING

Chemiseal Type 810 TEFLON V-Packing for use in manual, air or motor operated valves. Distinctive tapered V design offers greater flexibility and resiliency, providing necessary seal at low gland pressure and reduced torque on valve stem.

CUP AND CONE TYPE PACKING

Chemiseal Type 810-W TEFLON Packing for both hand and mechanically operated valves. Cones deform inwardly to effect a seal at the spindle, while cups expand outwardly against stuffing box wall, making possible a tight seal at low gland pressure.



WEDGE TYPE PACKING

Chemiseal Type 810-WX Packing offers the unusually low gland load required for valves made of Haveg, Karbate, ceramics, etc. Rings provide space for thermal expansion. Also adaptable for spring loading wherever exceptionally low friction load is required.

PUMP PACKING

For general purpose or non-contaminating pump service throughout the processing industries, order Chemiseal Types 711-G, (graphite, impregnated) No. 711-M (impregnated with mica), and No. 711-0 (pure TEFLON).

Write for Catalog No. TP-1053.

made of duPont TEFLON

UNITED STATES GASKET CO. Camden 1, New Jersey

UGS

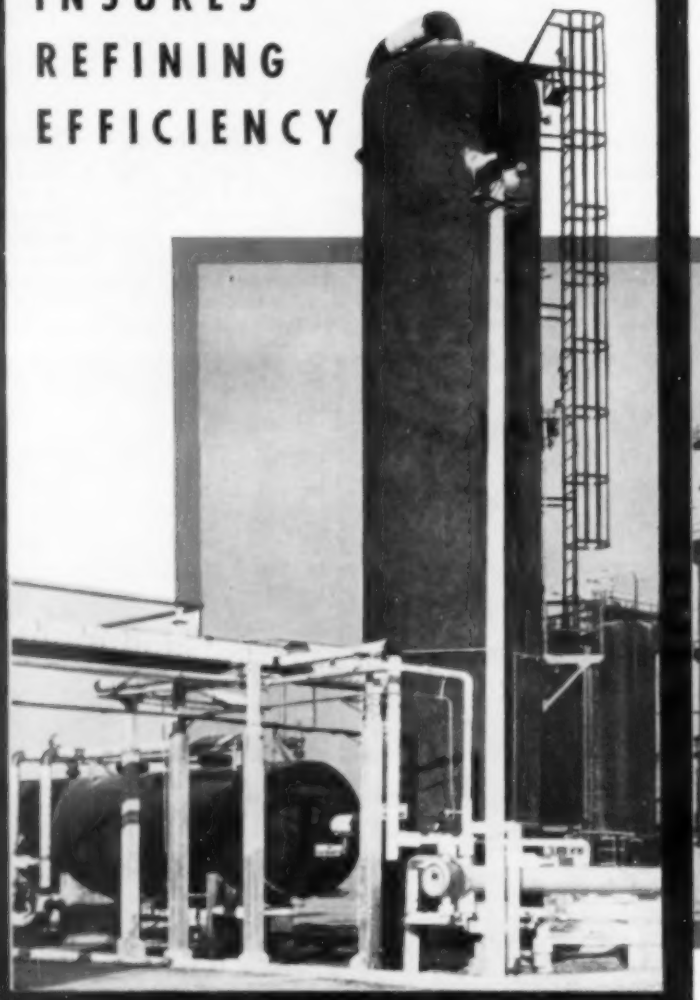
FABRICATORS OF FLUOROCARBONS AND OTHER PLASTICS

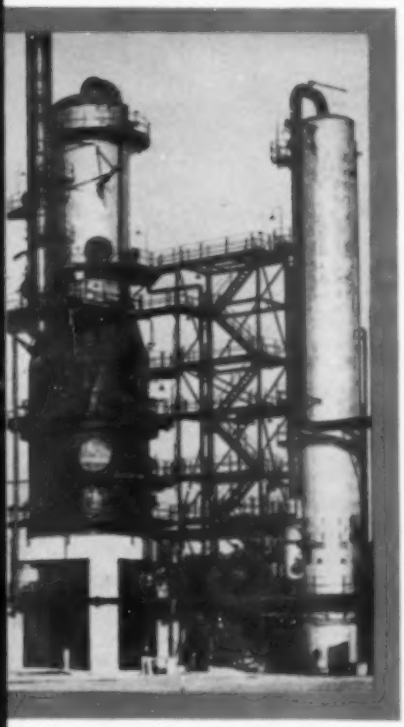
Representatives in principal cities throughout the world

(To obtain more data on advertised products see page 1252)

TRETOLITE DESALTING

INSURES REFINING EFFICIENCY





The many* refiners who depend on Tretolite for efficient salt removal know that their refining operations will be free from difficulties caused by salt because Tretolite desalting removes from 97 to 100% of the salt.

* Tretolite desalting currently is used to desalt over one and one half million barrels of contaminated crude per day.

As an additional insurance against lost refining efficiency caused by corrosion damage, ask your Tretolite Refinery Engineer about Kontol Corrosion Preventives. They are effective, economical, and proved.

In addition to assured high-percentage salt removal, Tretolite desalting offers these advantages:

1. *The low treating cost per barrel results in economical operations.*
2. *The simplicity of the process assures a low installation cost.*
3. *Flexibility of operation permits the desalting of various crudes with varying salt contents.*
4. *Emulsion resolution is thorough, resulting in a clean water effluent.*
5. *Solids such as sand, silt and drilling mud are effectively removed, preventing plugging and erosion.*
6. *Catalyst poisons such as arsenic and trace metals are substantially reduced, preventing catalyst contamination.*

TR 5526

TRETOLITE COMPANY

A DIVISION OF PETROLITE CORPORATION

369 Marshall Avenue, St. Louis 19, Missouri • 5515 Telegraph Road, Los Angeles 22, California

Specialized Chemicals and Services for the Petroleum Industry

DEMULSIFYING • DESALTING • WATER DE-OILING
CORROSION INHIBITING • PARAFFIN REMOVAL • SCALE PREVENTION • PRODUCTION STIMULATION

STEEPLEJILL Eddie May Youell checks the paint on a flagpole at the Dow Chemical Co., part of the service her firm performs every two or three years as paint contractor for the company's Texas Division. Eddie owns her own firm, Youell Steeplejack Service, Houston.

Davison Wins R. I. of A. Award

Plant committees with equal representation of management and workers have won the Davison Chemical Co. the annual award of the Associate Membership Div. of the Research Institute of America. This award is given for practical solutions to problems in the field of human relations, company communications and manpower utilization.

The citation noted that the plant committees "give self-expression to daily plant problems, help direct management's attention to employee ideas, and act as a window through which management becomes better acquainted with employee problems as they appear to the employee."

New Oil-Shale Engineers

Cameron and Jones is a new engineering firm which specializes in oil-shale technology. Russell J. Cameron, John B. Jones, and Arthur Matzick, an associate, formerly were senior staff members of the U. S. Bureau of Mines oil-shale experiment station at Rifle, Colo.

The group has had experience in all phases of oil-shale handling and processing and offers these specific services: process design, process development, economic evaluation, plant engineering and operation, and general consultation.

Offices of Cameron and Jones are at 100 E. Jefferson, Englewood, Colo.

Beckman Buys Liston-Becker

Beckman Instruments, Inc., has gone into new fields of instrumentation and automation with the purchase of Liston-Becker Instrument Co., manufacturers of infrared gas analyzers and electronic amplifiers.

Another recent purchase by the Beckman firm was the Specialized Instrument Co. of Belmont, Calif., which is a leading manufacturer of ultracentrifuges.

Max Liston, founder of Liston-Becker, will continue as manager of the firm, and no change in personnel or plant location is contemplated.

Houdry Shifts Four

Four staff changes have been made by Houdry Process Corp. in connection with the expansion and establishment of its new chemical division. The division makes and markets catalysts for use in petroleum refining and other industries.

Theodore A. Burtis, supervisor of process engineering, has become associate manager of research and development at the corporation's Linwood, Pa., laboratories.

Joseph W. Schall, director of development, is now assistant manager of marketing in the new division.

George W. Higginson, assistant manager of catalyst manufacture, has been appointed assistant manager of manufacturing in the chemical division.

Julius J. Cicalese, senior process engineer, has been made supervisor of process engineering.

C&H Acquires Canadian Firm

A Canadian subsidiary has been acquired by Calumet & Hecla to produce the Wolverine Tube Division's equipment in that country. Canada Vulcanizer & Equipment Co., the new concern, is operating as a wholly owned subsidiary of Wolverine Tube's Detroit operations.

The new subsidiary makes Wolverine's patented finned tubing and builds heat transfer equipment incorporating the tubing. The firm also continues to make its vulcanizing equipment in a wide range of sizes.

D. D. C. McGeachy continues as president and general manager of Canada Vulcanizer.

Women Engineers Make Award

The Society of Women Engineers has given its 1955 award for meritorious contribution to engineering to Dr. Margaret H. Hutchinson, chemical consultant for Stone and Webster Engineering Corp.

Dr. Hutchinson

Dr. Hutchinson was graduated with a B.S. degree from the Rice Institute, where she also received her degree as chemical engineer. She obtained a Ph.D. in chemical engineering at M.I.T. and is believed to be the only woman ever to have been given such a degree at the school.

Research and development in fractionator design are the principal interests of Dr. Hutchinson at present. She has been active in design work for the petrochemical industry for a number of years. Some of the original investigations of the effect of liquid flow on bubble tray capacity were conducted by Dr. Hutchinson and coworkers and embodied in the first paper on the subject which was delivered before the pertroleum section of the American Chemical Society.

Dr. Hutchinson is an active member of the American Institute of Chemical Engineers, a member of the Society of Women Engineers, the National Society of Professional Engineers and others. In private life, she is Mrs. W. C. Rousseau and lives with her husband (also an engineer) and 8½-year-old son in Reading, Mass.

Ehrhart & Arthur Alters Name

Ehrhart & Associates, Inc., is the new name of the former Ehrhart & Arthur, Inc., engineers and constructors of petroleum refineries and chemical process units. The change of name involves no change in ownership or scope of operations, the company reports.

Fisher Buys Thermo Co. Assets

Fisher Governor Co., of Marshalltown, Ia., has acquired the assets of the Thermo Instruments Co., Belmont, Calif. The purchase will add Thermo's

line of capacitance probe-type liquid level measurement instruments to Fisher's products.

The former president of Thermo, D. M. Comb, is currently associated with Fisher at the Marshalltown location.

Wyatt Offers Storage Tanks

Wyatt Metal & Boiler Works, of Houston and Dallas, has taken up the manufacture of floating roof storage tanks. Three new types of floating roof tanks will be offered; in general they are of the twin-deck, pontoon and pan-type designs. They will be made under license of the Joor group of patents.

The Wyatt firm also produces a line of all-welded storage tanks.

B-J Expands Seals Division

Byron Jackson Co. has reorganized and expanded its mechanical seal product division, which includes the mechanical seal laboratory. H. E. Tracy has been named manager, and D. F. Strang product manager of the division.

R. E. Farrell will concentrate his efforts on seal development and will work both in the engineering department and the laboratory. The division will place additional engineering emphasis on new designs for special applications as well as on general research and development.

The mechanical seal laboratory is being completely refitted with additional high-pressure pumping equipment, a new-type tester, and the engineering section is being enlarged.

Rockwell Builds New Plant

A new parts plant is on the way up in Russellville, Ky., for Rockwell Manufacturing Co. Expected to cost in excess of $1,000,000, the plant is scheduled for completion early next year. It will turn out parts for all Rockwell products, including Nordstrom lubricated plug valves and liquid meters.

The one-story building will contain 104,000 sq. ft. of space.

Hooker to Build in Vancouver

The first chlorine-caustic soda plant on the west coast of Canada will be built very shortly by Hooker Chemicals, Ltd., of Vancouver, B. C., a subsidiary of Hooker Electrochemical Co. Production at the plant, which will cost an estimated $11,000,000, is expected to begin in early 1957. This region in Canada has been supplied with chlorine and caustic soda by

(To obtain more data on advertised products see page 1252)

barge and tank car from another Hooker Electrochemical plant in Tacoma, Wash.

The new plant will utilize the company's newly constructed 200,000-gal. bulk storage facilities for handling liquid caustic soda, located on the outskirts of Vancouver.

Personnel Changes

Tellepsen Petro-Chem Constructors—Adolph M. Cuellar to process engineer, from senior chemical engineer at American Republics Corp.

Crane Co.—Frank F. Elliot to president, succeeding John L. Holloway.

B-I-F Industries, Inc. — M. H. Strickland to manager of industrial sales for the Chicago district, which now handles the complete line of equipment for Proportioneers, Inc., manufacturers of chemical feeders and automatic blenders.

Davison Chemical Co.—John D. Odle to research and development, division, assigned to the Curtis Bay plant at Baltimore.

American Cyanamid Co.—Ben H. Loper to Chicago sales representative, C. O. Brown, Jr., to New York sales representative, and Read Larson to assistant to the department's technical director. All are in refinery chemicals department of the industrial chemicals division.

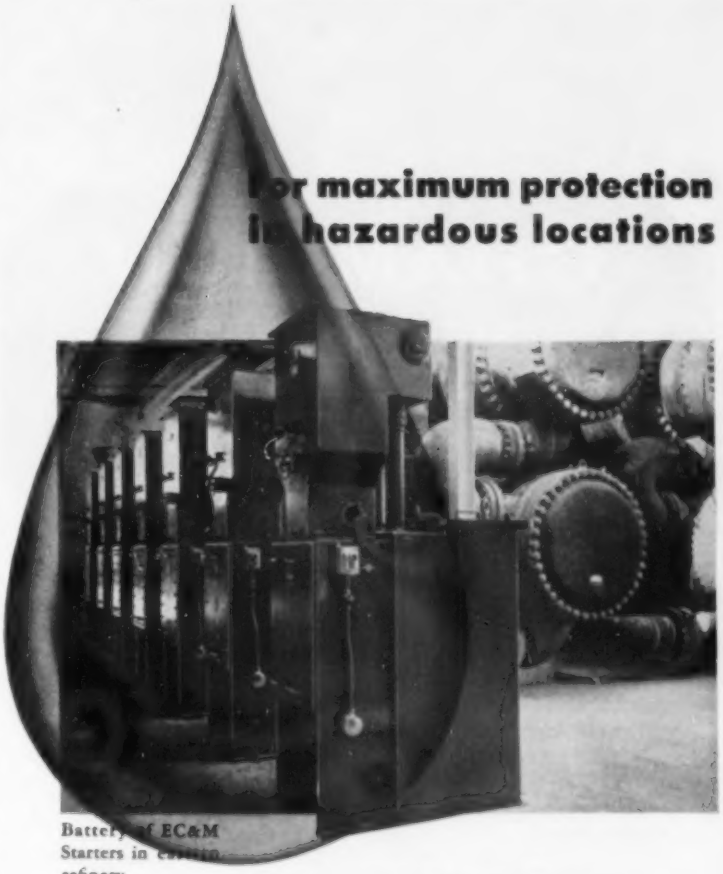
Climax Molybdenum Co.—J. Richard Milliken to the metallurgical development division as a specialist on the process industries and petroleum refining.

ElectroData Corp. — John W. Thatcher to customer service manager.

Haynes Stellite Co.—Frederick C. Kroft to general superintendent of manufacturing. Haynes is a division of Union Carbide and Carbon Corp.

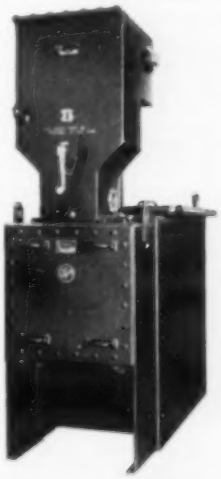
Delta Tank Manufacturing Co.—Joe E. Ketner to vice-president and general manager. Three other new vice-presidents are: Ross B. Baze, sales manager of oil field equipment and special order products division; Max Fetty, advertising and sales promotion manager; and Jack Harelson, manager of the Macon, Ga., plant.

Allied Chemical & Dye Corp.—Andrew S. Clark to construction manager, engineering division, of Solvay Process Division; Solon D. Fisher to



Battery of EC&M Starters in [illegible] refinery.

OIL-IMMERSED
50,000 KVA INTERRUPTING CAPACITY
MOTOR STARTERS
BY EC&M



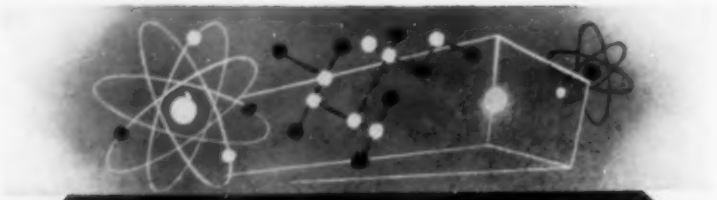
This installation is another example of the increasing acceptance of EC&M oil-immersed Motor Starters by refinery engineers and construction and design companies. The inherent advantages of these starters are high interrupting capacity (50,000 kva or VALIMITOR type for bus of unlimited kva) and assurance of a compact, neat installation.

These slender space-saving starters with self-contained Oil Disconnect Switch require less floor space . . . result in greater area around each unit for inspection and maintenance.

Write for illustrated 16-page Booklet 6062 for full details.

THE ELECTRIC CONTROLLER & MFG. CO.
4498 Lee Road, Cleveland 28, Ohio

(To obtain more data on advertised products see page 1252)



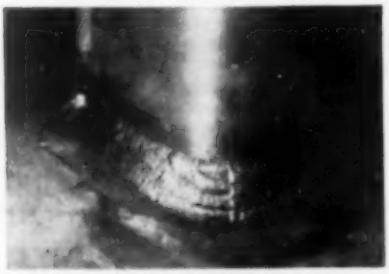
CHAMPION
brings you the
WELDING ELECTRODES
of the Future . . . TODAY!!

Whatever your requirements in an arc welding electrode, CHAMPION'S Research and Engineering have designed a product that is tops in its class.

All CHAMPION ELECTRODES, whether MILD STEEL • IRON POWDER CONTACT • LOW ALLOY - HIGH TENSILE • LOW HYDROGEN • STAINLESS STEEL or HARD SURFACING have built in quality and excellence of performance.

We are especially proud in bringing to the fabricator **CHAMPION CROLOY ELECTRODES** which greatly minimize all of the problems formerly encountered in welding of chrome-moly steels. They offer —

Exceptional ease of handling in all positions. Highest possible mechanical properties; both as welded and stress relieved. Pass the most rigid radiographic examination. Reduce the former rigid restrictions on pre-heat and post-heat.



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For the full story on CHAMPION CROLOY or any of the other outstanding CHAMPION ELECTRODES mail your letterhead request at once to Dept. PR.

THE CHAMPION RIVET COMPANY
CLEVELAND 5, OHIO — EAST CHICAGO, INDIANA

Suppliers

technical assistant to the manager of the ammonium and potassium section, Solvay Process Division.

Panellit, Inc.—T. A. Hislop to chief engineer of the new Canadian affiliate, Panellit of Canada, located at 60 Newcastle St., Toronto.

Rockwell Manufacturing Co.—Orville W. Barnett, manager of Nordstrom valve distribution and oil field sales, to assistant to the vice-president of the Meter and Valve Division.

Branches, Distributors

Edward Valves has named F. J. Hearty & Co. representative in Nevada, Arizona and California. Edward Valves is a subsidiary of Rockwell Manufacturing Co.

Hammel-Dahl Co. has appointed MacGuire Instrument Co. in Cayce, S. C., sales and service representative of its automatic control equipment.

Expansion, Transition

Pennsylvania Salt Mfg. Co. has moved its executive offices from the Widener Building to 3 Penn Center Plaza, Philadelphia. Included in the move were Sharples Chemical Division, Industrial Chemicals Division and others.

Davison Chemical Co. has opened an office at 199 Bay St., Toronto, to direct sales in Canada of petroleum cracking catalysts. Alan W. Bennett has joined the company to take charge of the office.

Jefferson Chemical Co. has transferred its headquarters offices and 50 employees from New York to Houston, Texas. New office is at 411 Fannin St. Jefferson still maintains a sales office in New York.

ElectroData Corp. has set up a southwestern regional sales and service office in Dallas at 4515 Prentice St. Kenneth L. Austin has been named manager.

Calumet & Hecla, Wolverine Tube Division, has moved its Chicago area sales offices to 1580 Sherman Ave., rm. 406-410, Evanston, Ill.

Dodge & Olcott, Inc., has transferred the San Francisco sales office to 503 Market St., San Francisco 5, Calif.

ISA Conference to Hear 100 Papers

ONE of the largest instrument-automation conference and exhibits in the history of the Instrument Society of America is planned for the week of September 12 to 16 at the Shrine Auditorium in Los Angeles. There will be about 100 papers delivered in 33 sessions, and many of these are likely to be of special interest to the petroleum refining industry.

Papers of special interest to be read on Monday, September 12, are the following:

"Controlled Volume Pumps Are Flow Control Instruments," by Robert T. Sheen, Milton Roy Co.

"Application of Principles of Instrumentation to Liquid and Dry Feeders," by Paul Coffman, Omega Machine Co.

"Orifice Plate Errors Due to Pulsative Gas Flow," by Charles Newman, Fluor Corp.

"Process Control by End-Point Analysis and Associated Data Reduction Systems," by Sibyl M. Rock, Electro Data Corp., and Jack Walker, Consolidated Engineering Corp.

Tuesday's sessions will offer the following among the scheduled papers:

"Dynamics of Pneumatic Control System," by Page S. Buckley, du Pont Co.

"Chemical Plant Controls Respond to Dynamic Analysis," by Carl Sanders, du Pont Co.

"Instrument Application of Statistical Analytical Techniques," by R. F. Mahood, du Pont Co.

"Application of Mass Spectrometry to Refinery Control," by J. K. Walker, Consolidated Engineering Corp.

Some especially interesting papers on Wednesday, September 14, are:

"Natural Gasoline Plant Instrumentation," by Elmer Kleir, Foxboro Co.

"The Economics of Instrumentation in the Oil Refinery," by Harry Moore, Esso Research and Engineering Co.

"A Systematic Approach to Automatic Process Control," R. L. McCarthy, du Pont Co.

"Dynamic Analysis and Control of a Process Pump," by Robert P. Bigliano, du Pont Co.

"The Dynamic Response of a Process Analyzer With Its Associated Sampling System," by Elliot Woodhull, Perkin-Elmer Corp.

"Analysis of Automatic pH Control," by Larry Silva and H. J. Noebels, Beckman Instruments.

"A Preliminary Dynamic Study of Furfural Extractive Distillation Column Control," by D. E. Berger, Phillips Petroleum Co., and G. G. Campbell, Phillips Chemical Co.

Papers to be read on Thursday, September 15, will include the following:

"All-Electronic Mass Flowmeter," by Nathaniel Brewer, Fischer & Porter Co.

"An Ultrasonic Flowmeter for Liquids," by Jack Kritz, W. L. Maxson Corp.

"Meeting Sampling System Requirements for Continuous Gas Analyzers," by P. D. Schnelle, du Pont Co.

"Proposed Plant Stream Sampling for Mass Spectrometer," by Joseph G. Neuland, Beckman Instruments, Inc.

"How to Sample Liquid Streams for Monitoring Dielectric Constant and Viscosity," by B. W. Thomas, N. F. Chamberlain, O. J. Howell, and R. L. Martin, Humble Oil and Refining Co.

"A Method for Continuous Subatmospheric Sampling for a Process Monitor Mass Spectrometer," by E. E. Escher and Henry Landsberg, Consolidated Engineering Corp.

"A Sampling System for an RF Process Monitor Mass Spectrometer," by R. E. Wightman, W. D. Peters, and L. A. Grundy, Phillips Petroleum Co.

"Experience in Sampling Plant Gas Streams for Analysis Measurement," by R. K. Davis and J. L. Serrill, Leeds & Northrup Co.

Three papers should be of special interest to refiners on Friday. They are:

"Digital Handling of Analog Data," by Bernard Gordon, Epsco Inc.

"Automatic Data Transmitting System," by James R. Cunningham, Beckman Instruments, Inc.

"Functional Considerations of an Inexpensive Electronic Computer," by Chalmer E. Jones, Heath Co.

"Integration" a Topic at AIChE Lake Placid Meeting

Growth by integration of the oil and chemical industries will be examined at the American Institute of Chemical Engineers' Lake Placid, N.Y., meeting September 26 to 28.

The symposium on integration will be presided over by F. M. Simpson, president of Petroleum Chemicals, Inc. The first speaker will be John G. McLean, Harvard University, who will address the group on "Integration in the Oil Industry." He will be followed by S. A. Swensrud, Gulf Oil Co., who will speak on "Growth by Integration: Gulf Oil—A Case History." Other speakers will give the story of integration in the chemical industry.

Other symposiums to be given at the meeting, and selected papers of interest to the refining industry, follow:

Packaged Power

"Has the Small Gas Turbine an Industrial Future?" by P. L. Ward, Solar Aircraft Co.

Broad Social Competence of Engineers

Atoms for Profit

"The Reprocessing Factor in Nuclear Power," by George White, Vitro Corp. of America.

Chemical Engineering Organizations of the Future

"Educating the Chemical Engineer of the Future," by Joseph C. Elgin, Princeton University.

"The Future of Automatic Information Handling in Chemical Engineering," by C. R. DeCarlo, International Business Machine Corp.

"The Future Relationship of Nuclear and Chemical Engineering," by C. Rogers McCullough, Monsanto Chemical Co.

"What May We Expect of Chemical Engineers in the Future," by Bruce K. Brown, Pan-Am Southern Corp.

The meeting will be held in the Lake Placid Club and some 500 engineers are expected to attend.

IOCA to Hear About New Motor Oil Detergent

A new motor oil compounding detergent with special value for "stop and go" automobile driving will be among the topics at the annual meeting of the Independent Oil Compounders Association September 26 and 27. Site of the meeting will be the Bismark Hotel in Chicago.

John R. Griffin of du Pont will discuss the new detergent which was developed by his company.

The meeting will feature a total of six speakers, but only two others have been announced. Their topics are:

"Lubricating Greases—Their Manufacture and Proper Application," by H. L. Hemmingway, general manager, sales dept., The Pure Oil Co., and president of the National Lubricating Grease Institute.

"Synthetic Lubricants and Their Place in the Independent Oil Compounder's Future," by A. W. Ackerman, research director of the F. E. Anderson Oil Co.

SRI Offers Symposium on Automation Aug. 22 and 23

A symposium on "Electronics and Automatic Production" will be held at the Sheraton-Palace Hotel in San Francisco on August 22 and 23. Joint sponsors of the event are Stanford Research Institute and the National Industrial Conference Board.

The broad view of the subject will be taken up in the first session, "Automation—What Is It?" Next, opportunities and problems in various industries will be discussed. The automotive industry, steel, chemicals, and electronics will be taken up in detail.

The second day of the symposium will open with a session on "Automatic Handling of Business Data," in which representatives of industry will tell about the success of this technique in collecting business statistics, in insurance, accounting, and publishing.

The social and economic implications of automatic production will be dealt with in the afternoon session.

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Oil Man's Calendar

AUGUST

Society of Automotive Engineers, golden anniversary West Coast meeting, Hotel Multnomah, Portland, Oregon, August 15-17.

Electronics and Automatic Production Symposium, sponsored by Stanford Research Institute and the National Industrial Conference Board, Sheraton-Palace Hotel, San Francisco, Aug. 22-23.

SEPTEMBER

Petroleum Industry Conference, sponsored by the American Institute of Electrical Engineers, Shamrock Hotel, Houston, Sept. 12-14.

Instrument Society of America, 10th national instrument conference and exhibit, Los Angeles, Sept. 12-16.

National Petroleum Assn., annual meeting, Traymore Hotel, Atlantic City, Sept. 14-16.

Western Petroleum Refiners Assn., regional technical-industrial relations meeting, Casper, Wyo., Sept. 22-23.

American Institute of Chemical Engineers, Lake Placid Club, Lake Placid, N.Y., Sept. 25-28.

Petroleum Conference, American Society of Mechanical Engineers, Roosevelt Hotel, New Orleans, Sept. 25-28.

Natural Gasoline Assn. of America, Oklahoma regional meeting, Skirvan Hotel, Oklahoma City, Sept. 29.

OCTOBER

American Society of Mechanical Engineers, petroleum branch, fall meeting, Roosevelt Hotel, New Orleans, Oct. 2-5.

American Society for Testing Materials, Committee D-2, petroleum products and lubricants, Statler Hotel, Washington, D.C., Oct. 2-6.

Lubrication Conference, sponsored by the American Society of Mechanical Engineers and the American Society of Lubrication Engineers, Antler's Hotel, Indianapolis, Ind., Oct. 10-12.

American Oil Chemists' Society, fall meeting, Hotel Bellevue Stratford, Philadelphia, Oct. 10-12.

American Gas Assn., annual convention, Los Angeles, Oct. 17-19.

Western Petroleum Refiners Assn., regional technical-industrial relations meeting, Garret Hotel, El Dorado, Ark., Oct. 20-21.

Combustion Conference, sponsored by the American Society of Mechanical Engineers and the Institute of Mechanical Engineers, at the Institution of Civil Engineers, London, Oct. 25-27.

Instrument Society of America, Philadelphia Section, "Automatic Control Loops—Electronic or Pneumatic?", Penn Sherwood Hotel, Philadelphia, Oct. 28-29.

National Lubricating Grease Institute, annual meeting, Edgewater Beach Hotel, Chicago, Oct. 31-Nov. 2.

NOVEMBER

Society of Automotive Engineers, golden anniversary diesel engine meeting, The Chase, St. Louis, Nov. 2-4.

Society of Automotive Engineers, golden anniversary fuels and lubrication meeting, Hotel Bellevue Stratford, Philadelphia, Nov. 9-10.

American Petroleum Institute, annual meeting, Mark Hopkins, Fairmont, St. Francis, and Palace Hotels, San Francisco, Nov. 14-17.

American Institute of Chemical Engineers, annual meeting, Statler Hotel, Detroit, Nov. 27-30.

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ALLOYS, for severe corrosive conditions, booklet; Haynes Stellite Co. See adv't. p. 1263.

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CATALYTIC REFORMING, brochure describes "Catforming;" Atlantic Refining Co. See adv't. p. 1222.

CLAY, for protection against platinum catalyst poisoning, booklet; Minerals & Chemicals Corp. See adv't. p. 1115.

CUPRIC CHLORIDE, for sulfur removal, samples on request; Tennessee Corp. See adv't. p. 1210.

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GAGE ILLUMINATORS, explosion proof, data unit; Jerguson Gage & Valve Co. See adv't. p. 1224.

INSULATION, high and low temperature types, booklet; Armstrong Cork Co. See adv't. p. 1259.

INSULATION, industrial, pipe and block, folder; Philip Carey Mfg. Co. See adv't. p. 1251.

LIQUID LEVEL CONTROL, bulletin F-3; Fisher Governor Co. See adv't. p. 1248.

LIQUID SEPARATOR FILTER, for water removal, bulletin; Warner Lewis Co. See adv't. p. 1109.

MASS SPECTROMETER, brochure CEC 1800C-X13; Consolidated Engineering Corp. See adv't. p. 1260.

MECHANICAL SEALS, for severe conditions, catalog 455-PP; Durametallic Corp. See adv't. p. 1278.

METAL DEACTIVATOR, to control copper compounds, technical data and samples; Tretolite Co. See adv't. pp. 1124A-1124B.

MIXERS, side and top entering, 8 catalogs and data sheets; Mixing Equipment Co. See adv't. p. 1138.

MOTOR STARTERS, for hazardous locations, booklet 6062; The Electric Controller & Mfg. Co. See adv't. p. 1245.

OXYGEN ANALYZER, continuous direct measurement, data file 16J-85; A. O. Beckman, Inc. See adv't. p. 1264.

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PAINT, aluminum, booklets; Aluminum Co. of America. See adv't. p. 1127.

PIPE AND FITTINGS, aluminum, booklet; Aluminum Co. of America. See adv't. p. 1255.

PRESSURE RELIEF, for low pressure applications, literature; Black, Sivalls & Bryson, Inc. See adv't. p. 1104.

PUMPS, jacketed, vertical, bulletin 203-7; Lawrence Pumps, Inc. See adv't. p. 1276.

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PUMPS, stuffingboxless, high pressure, bulletin 107; Bingham Pump Co. See adv't. p. 1220.

STAINLESS STEEL, for refinery applications, booklet; U. S. Steel Corp. See adv't. p. 1124.

STEAM TRAPS, cast and forged, catalog J; Armstrong Machine Works. See adv't. p. 1128.

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STEEL FABRICATION, for refineries, general catalog; Flint Steel Corp. See adv't. p. 1239.

SWING JOINTS, ball bearing, catalog 400; Barco Mfg. Co. See adv't. p. 1230.

TANK GAUGE, electronic, booklets; Gilbert & Barker Mfg. Co. See adv't. p. 1118.

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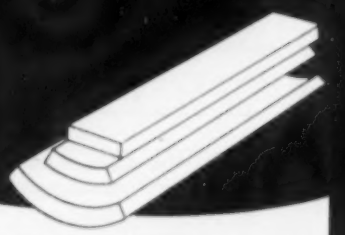

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2	1	1½	2	2½	2½	3
2½	1	1½	2	2½	3	3½
3	1	1½	2	3	3	3½
3½	1	1½	2	3	3½	3½
4	1	1½	2½	3	3½	4
4½	1½	2	2½	3	3½	4
5	1½	2	2½	3	3½	4
6	1½	2	2½	3½	4	4½
7	1½	2	2½	3½	4	4½
8	1½	2	3	3½	4	4½
9	1½	2	3	3½	4½	5
10	1½	2½	3	4	4½	5
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A5	B5	C5	D5	E5	F5	G5	H5	I5	J5	K5	L5	M5	N5	O5	P5
A6	B6	C6	D6	E6	F6	G6	H6	I6	J6	K6	L6	M6	N6	O6	P6
A7	B7	C7	D7	E7	F7	G7	H7	I7	J7	K7	L7	M7	N7	O7	P7
A8	B8	C8	D8	E8	F8	G8	H8	I8	J8	K8	L8	M8	N8	O8	P8
A9	B9	C9	D9	E9	F9	G9	H9	I9	J9	K9	L9	M9	N9	O9	P9

PETROLEUM PROCESSING
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8/55

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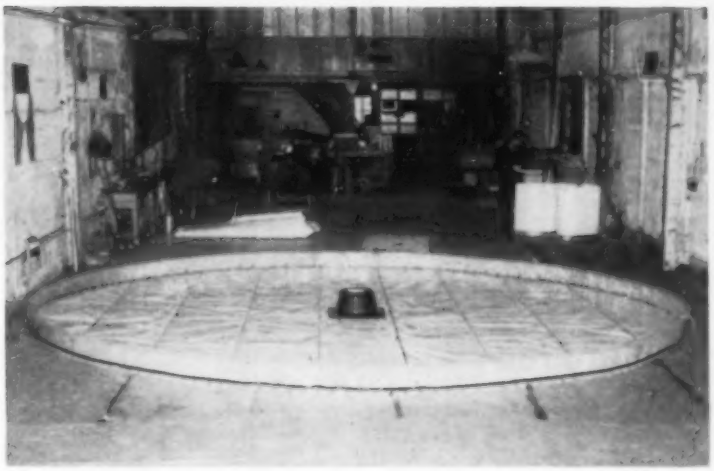
WHAT'S NEW...



Plastic Blanket Cuts Evaporation

A new aid to reducing evaporation losses from tanks storing volatile liquids has been introduced in the U. S. by Societe LaRoche Freres, a French company in Paris.

Consisting of a polyvinyl chloride blanket fitted with a vapor-sealing skirt, the evaporation reducer is effective for crude petroleum, gasoline, alcohol, etc., tankage. Evaporation during test runs did not exceed 10-20% of the losses experienced in tanks without the blanket.

The blanket is already in use in the British Petroleum Co. refinery at Dunkerque, France, and several U. S. refineries are considering its use.

Blanket construction consists of a continuous flexible "carpet" covering the free liquid surface up to within one inch of the tank wall, and a "Z"-shaped skirt around the edge of the carpet to form a vapor seal against the side of the tank.

The "carpet" bottom is provided with a large number of small parallelepipedic floats arranged side by side. The vertical skirt not only insures a vapor seal against the tank wall, but has sufficient elasticity to allow the seal to conform to tank wall irregularities, such as rivets, etc.

Openings, fitted with vertical sleeves, are provided in the blanket to allow measuring and sampling, and to allow the level indicator float to pass through. Small holes are provided every square yard to allow evacuation of condensation water.

PVC tubes attached below the screen prevent its dropping lower than the tank filling openings when the tank is empty.

For transportation, the floating screen is carried in sections, measuring about 25 x 48 ft., cylindrically rolled in 25-ft. lengths. This form is also convenient for insertion of the blanket through a tank man hole during installation. Specialized operators provided by the supplying company will install the blanket.

Electrostatic charges in the storage tank—built up during filling—are eliminated by means of a continuous wire netting on the blanket, the netting being grounded by flexible conductor cables. This netting serves to trap all electrostatic charges on the surface of the liquid, thus providing a protection not found in tanks without the grounded blanket.

In rare cases where the air-vapor concentration in the vapor space above the blanket is in the explosive range after installation of the blanket, a special venting device is furnished which will fit over any opening already in the tank roof to reduce the vapor phase hydrocarbon concentration to a safe value.

The U. S. manufacturer of the floating plastic blanket is W. K. Archer Co., 75th and Cleveland Ave., Kansas City, Mo.

Circle No. **1** *on Reply Card*

For More Information

Use one of the attached reply cards to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers at the end of each item in which you are interested. Then fill in the rest of the card and drop it in the mail. No postage is required.

Hydrocarbon Sweeting

. . . using the "Bender Process" for gasoline, kerosine, jet fuel or No. 2 fuel. The process effects sweetening by converting mercaptans to disulphide by oxidation. In the process, sulfur is added to the distillate, plus a small amount of an alkali such as caustic or ammonia, plus air. The mixture is passed over a bed of solid catalyst, yielding a bright, sweet, non-corrosive product. The Bender Process has been extensively used by the Sinclair Refining Co. and its affiliated companies and is offered under Sinclair license by the Petreco Div. of Petrolite Corp. Petreco, P. O. Box 2546, Houston 1, Texas, or P. O. Box 7216, Long Beach 7, Calif.

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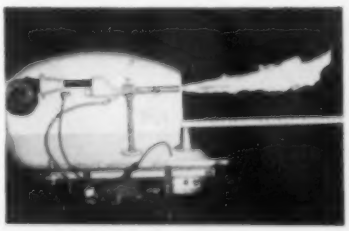
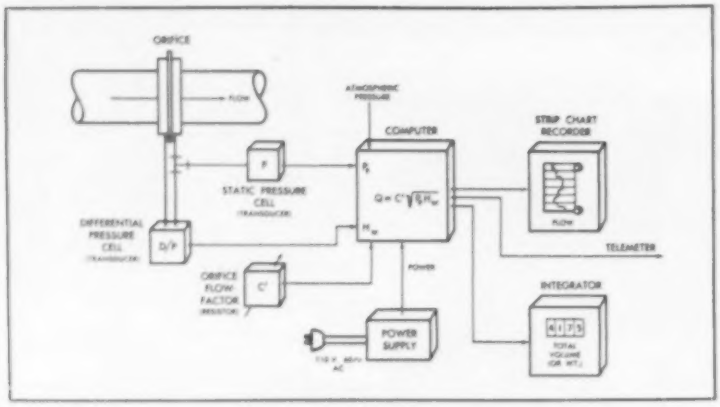


Burner Light-Off

. . . is sure and fast for commercial and heavy-oil industrial burners. "Faslite Torch" has a hard flame up to 25-in. long and is claimed to virtually eliminate the look-outs, "hard" starting and blow-backs attributed to lazy unstable pilot torch flames. An integral motor driven air-injection system makes the torch flame resistant to air turbulence to assure extension of the flame well into the fuel. The design allows substitution for old-type gas pilots on practically all commercial-industrial burner installations. Scully Signal Co., Melrose, Mass.

Circle No. **3** *on Reply Card*



Computer Reads Pulsating Flows

Flow rates and volumes of flow for gases or liquids can be measured using pressures—static and differential—to give direct readings. In essence, a computer has been inserted in the pressure measurement train between the orifice and the recorder or recorder-controller. In addition, an integrator may be used to give total volume over a period (or total weight), and the computer output may be used for pulse telemetering to remote locations. The device uses the conventional hook-up on the orifice of a D-P cell to furnish impulses to the computer.

Advantages include instantaneous readings as compared to manual data reduction of a regular recorder flow chart, and an accuracy of ±1% of maximum rated capacity over the operating range. The computer determines the true average value of pulsating flows at frequencies up to 500 pulsations per minute, and integrates over each cycle.

Computer output may be read directly or recorded. On special order the integrated total volume readings—displayed digitally—may be read out on printed tape, punched cards, etc. Contacts for pulse telemetering may also be provided, and the computer output may be used for automatic control of compressor speed or valve setting, etc.

Installation may be in connection with any existing orifice, and will compute the flow of any gas or liquid suitable for orifice metering. Operation is reliable over a wide ambient temperature range. Optional enclosures are available for hazardous, control room, or outdoor locations. Southwestern Industrial Electronics Co., Industrial Instruments Div., P. O. Box 13058, Houston, Texas.

Circle No. **4** *on Reply Card*

Glass Heat Exchangers

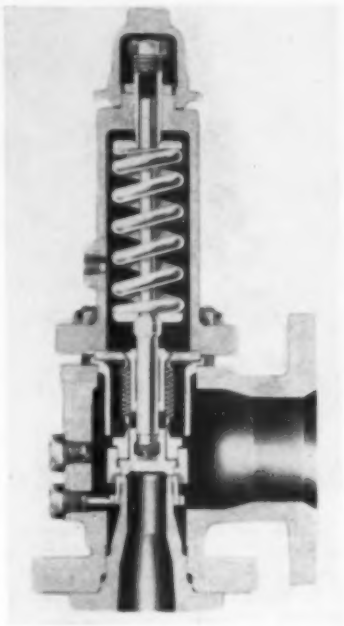
. . . **are made of Pyrex brand glass** to give a shell-and-tube heat exchanger which can be mounted easily in series or parallel, making possible optimum heat transfer and pressure drop in the processing system. The photo shows several Pyrex glass heat exchangers mounted in series. Corning Glass Works, Corning, N.Y.

Circle No. **5** *on Reply Card*

Copper Deactivator

. . . **decreases gum formation** in refinery products. Petroleum industry research has shown that copper in gasoline acts as a catalyst for oxidation which increases gum formation. The copper deactivator decreases the amount of anti-oxidant needed to prevent gum formation in gasolines containing trace copper. "Kuplex" deactivates copper in kerosine, diesel oil, home heating oil, jet fuel and turbine oil also, preventing product deterioration. The action of "Kuplex" is to combine with the copper metal and form a stable inactive chelate. Tretolite Co., 369 Marshall Ave., St. Louis 19, Mo.

Circle No. **6** *on Reply Card*



Bellows Relief Valve

. . . **is for corrosive services** where protection against corrosion, fouling of working parts, and low back pressure surges is required. The "Protecto-Seal Bellows Protector" shields the bellows from adverse turbulent effects from flowing media, preventing premature failure of the bellows due to fatigue. The protector also acts as a positive lift-stop preventing over-compensation of the bellows. The effective area of the valve seating surface is essentially balanced to nullify the effect of variable and constant back pressure. Moving parts of the valve are guided and held in alignment by a single member. The floating disc is loaded at a low point to insure alignment stability and seat tightness. The valve provides for simple maintenance, disassembly ease, and both seating surfaces can be reconditioned quickly in the field. The valve has been tested for performance and flow at pressures from 25 to 2500 psi. It is available in eleven orifice sizes and is furnished in 1-in. to 6-in. inlet sizes, in forged stainless steel full nozzle construction. Crosby Steam Gage & Valve Co., 43 Kendrick St., Wrentham, Mass.

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LIGHT WEIGHT FOR QUICK ASSEMBLY . . . ALCOA Aluminum Pipe weighs only one-third as much as carbon steel pipe. This means far easier handling of portable gathering lines . . . faster construction . . . easier, cheaper transportation of pipe . . . less work load in erection. (That's why farmers use ALCOA Aluminum Pipe for irrigation systems. *They* know savings when they see them.)

UNMATCHED FLEXIBILITY AND PORTABILITY make ALCOA Aluminum Pipe ideal for use in rough terrain. Leakproof couplings and fittings make assembly quick and easy. ALCOA Aluminum Pipe is strong, too . . . made in alloys equal to low carbon steel in mechanical strength. (That's why the construction industry uses portable aluminum pipe to bring compressed air to drills.)

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ALCOA Aluminum Pipe resists sulfur and hydrogen sulfide normally found in sour crude oil . . . does not cause sludging of lubricating oil or gum formation in gasoline. Because of its excellent properties at sub-zero temperatures, aluminum pipe is a natural for use in liquefied gas processes. It's nonsparking . . . may be used safely to carry inflammables.

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COSTS LESS PER FOOT, TOO . . . Compared with other corrosion-resistant metal pipe, ALCOA Aluminum Pipe is far cheaper per foot.

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Aluminum Company of America
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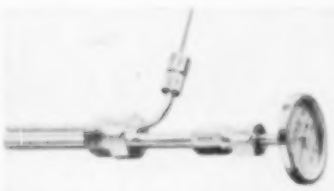
 (To obtain more data on advertised products see page 1252)

Tube Bundle Sling

. . . **made of flexible woven wire,** simplifies the handling of exchanger tube bundles in the refinery, as well as the handling of pipe in the field. The "Gripper" slings are made of a series of spiraled wires joined together so that adjacent spirals hinge across the body of the sling to provide flexibility and allow the sling to bend across its width. Thus the sling wraps completely around any load when rigged in a choke hitch and grips the entire load. Since the sling is fitted with heat treated male and female handles, it can be used in either a basket or choke hitch, and can be used for handling sharp-edged loads, as well as rounds, without damage to the sling. The slings are made from carbon steel and in standard lengths and widths with capacities up to 100,000 lb. Special sizes and corrosion resistant alloys are available on request. The Cambridge Wire Cloth Co., Cambridge, Md.

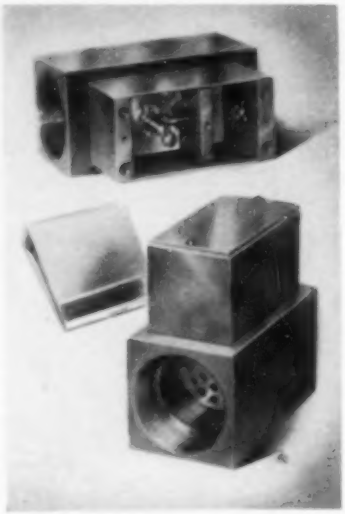
Circle No. **8** *on Reply Card*



Combination Check Well

. . . **has thermometer and thermocouple** to allow the accuracy of the thermocouple reading and the visual speed of the dial thermometer reading. The thermocouple protection tube protects the element from oxidation and corrosion caused by oxygen or toxic gases and permits changing or removing the thermocouple element with a minimum of time loss. Teflon is used as the standard sealant in both thermocouple and thermometer packing glands. Both protection tubes are made of 304 stainless steel and the process connection and packing glands are machined from type 303 stainless steel bar stock. Duplex thermocouples—20 or 24 gage insulated—are available in copper-constantan, chromel-alumel and iron-constantan. Conax Corp., 7811 Sheridan Drive, Buffalo 21, N.Y.

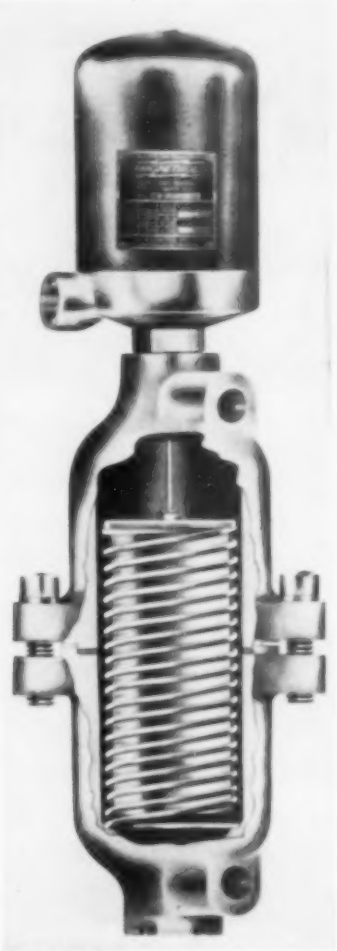
Circle No. **9** *on Reply Card*



Transducer Flowmeter

. . . **reads pulsating liquid flow** by combining a head-type, flow-sensing element and a high frequency-response, force transducer. The meter can be used with all types of corrosive and non-corrosive liquids at line pressures up to 2000 psi, and will measure either average or instantaneous flow at rates up to 8 gal./min. in a 1-in. diameter line. The flowmeter employs an orifice plate perforated with sixteen ⅛-in. holes and mounted on a hinged support inside a section of conduit. Fluid flow pressure acting upon the orifice plate is transmitted through a special force-transmitting seal to the force-sensing, strain-gage element of a standard pressure transducer. Line pressure effect is as low as 1 gram per 1000 psi. There are no moving parts. The sensing element operates with either a-c or d-c excitation voltages of 6, 12 or 15 volts. The amplifier-computer-indicator unit which receives the transducer impulse may be remotely located. Dynamic Instrument Co., Inc., 28 Carleton St., Cambridge, Mass.

Circle No. **10** *on Reply Card*



Liquid Level Control

. . . **is for high pressures,** and makes use of the basic principle of buoyancy obtained by displacement by a solid immersed in a liquid. A solid block displacer of glazed porcelain or Karbate "loads" its weight on a compression support spring. Rising liquid level imparts buoyancy to the displacer in proportion to the weight of the liquid it displaces to (first) "unload" the spring and (second) upon further rise, to produce the desired switch action. Conversely, falling liquid level subtracts buoyancy to cause low level switch action. Chambers are of cast steel of flanged design made to fit pressure requirements. Spiral wound asbestos or ring steel gaskets are furnished, and type 316 stainless steel compression springs for corrosive services are available. Inconel compression springs are available for temperatures up to 300° F. Model A-1501 is designed for pres-

POWELL VALVES . . . THE COMPLETE QUALITY LINE . . . POWELL VALVES

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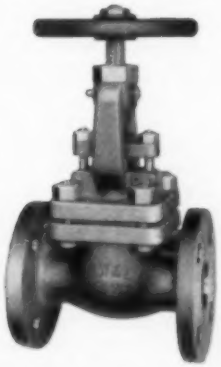
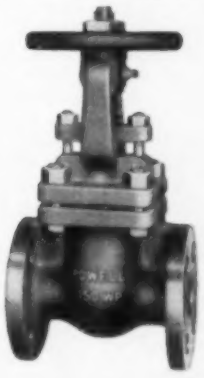
. . . THE COMPLETE QUALITY LINE . . . POWELL VALVES . . . THE COMPLETE QUALITY LINE . . .

FIG. 2342—Flanged End Bolted Cap Swing Check Valve for 150 Pounds W.P.

POWELL CORROSION RESISTANT VALVES

FIG. 2495—Double Disc Flanged End O.S.& Y. Gate Valve for 150 Pounds W.P.





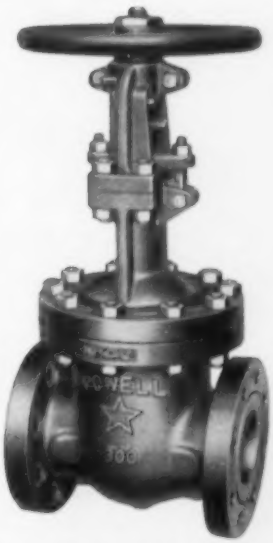


FIG. 2475—Stainless Steel O.S.& Y. Globe Valve for 150 Pounds W.P.

FIG. 3003SS—High Pressure Service Alloy Steel Gate Valve for 300 Pounds W.S.P.

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Powell can supply exactly the corrosion resistant valves you need . . . in a WIDE VARIETY of metal and alloys and all designs. You can be certain that every Powell Valve will give you dependable flow control.

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NEW HI-THRUPUT HERRINGBONED MIST ELIMINATOR

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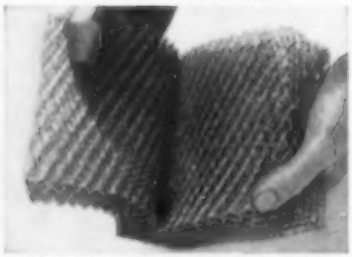
2. Safe operating limits — 10% to 12% higher velocity.
3. Entrainment removal practically 100% over wider operating range.
4. Three to four times longer on-stream life under coking conditions or where solids are present.
5. Lower cost — wires repositioned by Herringbone Fold*.

*U.S. Patent No. 2,565,846, Aug. 28, 1951



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Send for Revealing Booklet ME-5. Learn how repositioning wires by patented Herringbone process and change in size and contour of mesh openings make this new Mist Eliminator more effective and economical.

METAL TEXTILE CORPORATION

Roselle, New Jersey

Metal Textile Corporation of Canada, Ltd., Hamilton, Ont.

sures to 1500 psi, Model A-3001 for pressures to 3000 psi, and Model A-5001 for pressures up to 5000 psi. The control is designed to operate with liquids having specific gravities of 0.40 or greater. Magnetrol, Inc., Chicago, Ill.

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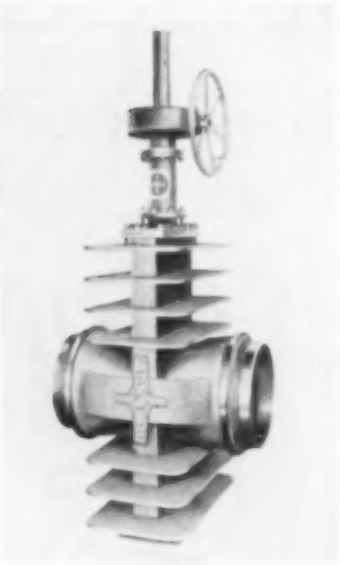

Gate Valves

. . . **having "O" ring sealed seats** to maintain bubble-tight seals on both upstream and downstream seats, is now available in sizes up to 36 in. for all petroleum and gas pipeline pressures. Featured is a new fabricated steel body design, with valves available with flanged or welding ends. The body may be vented or drained to provide positive indication of absolute shutoff. Standard models are listed from 2 in. to 36 in. in ASA Series 150, 300, 400 and 600. Grove Valve and Regulator Co., Oakland, Calif.

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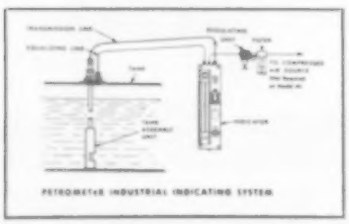

Liquid Depth Gauges

. . . **can be read remotely** and are designed for convenient, rapid installation on liquid storage tanks. Applicable in the petroleum, chemical, paint and food industries, they can be installed on tanks up to 50 ft. deep, located above or below the ground, and up to ¼ mile away. The "Series 1400 Petrometer Remote Reading Liquid Depth Gauge" operates on the principle of the hydrostatic pressure of the liquid within the storage tank. Pressure of the liquid weight in the tank is transmitted pneumatically through a copper tube transmission line to the liquid column in the indicator. Special features include a self-contained instrument panel, sealed indicating liquid to prevent spillage during transit, etc. All models are equipped with a push-button aerator valve for transmission line purging. Four models are available to cover applications where compressed air either is or is not available. Liquidepth Indicators, Inc., 43-22 Tenth St., Long Island City 1, N.Y.

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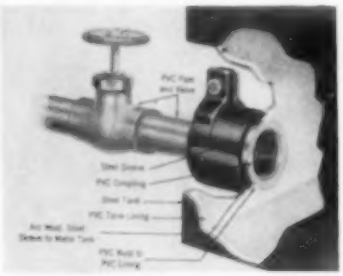

Plastic-Lined Valve

. . . **has polyvinyl chloride lining** to make a safe non-corroding tank outlet. The outlets provide a strong connection between PVC pipe and tanks lined with PVC, to prevent acid-to-metal contact. An exterior metal clamp, welded to the tank exterior, holds the PVC coupling rigid, eliminates stress on the PVC-welded joint between the coupling and the tank lining. Coupling sections and PVC tank linings have high resistance to nitric, muriatic, sulfuric, hydrochloric, hydrofluoric, and many other acids as well as resistance to chlorine gas and oxidizing agents. The PVC is rust and rot-proof, is unaffected by weather, and requires no coating or painting. The couplings are internally threaded in standard IPS sizes. The metal clamp is arc-welded to the metal tank. The PVC coupling is PVC-welded to a close-fitting hole in the PVC tank lining. Outlets are available in sizes from ½-in. to 2-in. diameters. S. & C. Manufacturing Co., Dept. 228, 6245 Wiehe Road, Cincinnati 13, Ohio.

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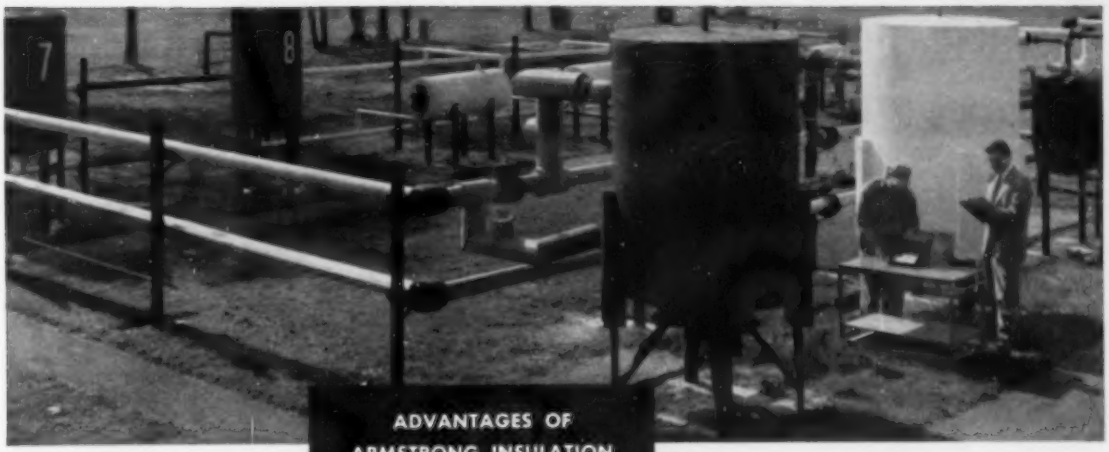

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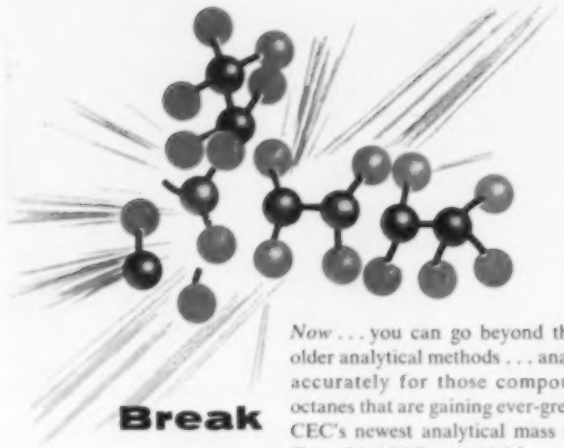

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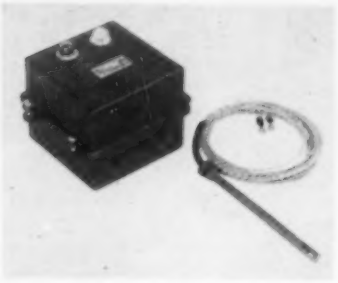
Sales and Service Offices Located in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

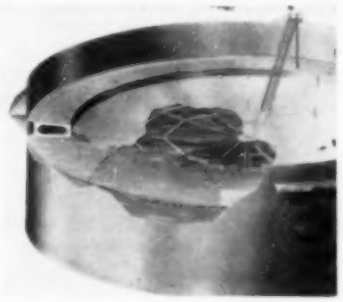
What's New!



Liquid-Sensing Unit

. . . detects presence of liquid in 4/10-sec. and absence of liquid in five seconds. Applications are for low-level warning or cutoff, to sequence liquid from one tank to another when predetermined levels are reached or merely indicate the presence or absence of liquid. Unit will operate visual or aural alarms, and control pumps, valves or motors in response to liquid level changes. It operates effectively in oil, water, liquid oxygen, gasoline, etc. with a model being developed for fuming nitric acid. The sensing element has no moving parts and no electrical contact is made with the liquid. Operating temperatures are from —319°F. to +200°F. Air Associates, Inc., Teterboro, N. J.

Circle No. **15** *on Reply Card*



Floating Roofs for Tanks

. . . **are of rigid design** to permit only moderate deflections, thus assure excellent drainage. The three types of floating roofs—licensed under the Joor group of patents—are of the twin-deck, pontoon (illustrated above) and pan-type designs. There is no space beneath the deck of the roofs where vapors may accumulate, thus lessening the possibility of corrosion of the deck plates. The annular space between the roof perimeter and the tank shell is sealed at the oil surface by synthetic-rubber-asbestos-cloth sealing material. The sealing mechanism consists of long, heavy galvanized steel shoe plates, and a positive, mechanical

Mathieson Caustic Soda: *why settle for less?*

In the lime-soda process—one of the two important methods of making caustic soda—the causticizing operation begins in huge settling tanks like those above. Here, a soda ash solution is treated with milk of lime, calcium carbonate is precipitated and a dilute caustic liquor obtained. This liquid is then filtered and concentrated to the commercial 50% and 73% solutions, as well as to the solid, flake, and granular forms. Lime-soda process caustic is produced at Lake Charles, La., and Saltville, Va.; four other strategically located plants produce electrolytic process caustic to make Mathieson a major source of this essential chemical raw material.

Multiple-process and multiple-plant facilities give Mathieson's caustic soda customers the dependability they want. It means their source of caustic is not controlled by seasonal fluctuations in chlorine demand as is sometimes the case when production is limited to the electrolytic caustic-chlorine process. This operational flexibility is also typical of other Mathieson chemicals—5 chlorine plants, 7 sulphuric acid plants, 3 alkali plants, 3 ammonia plants, provide a safety factor that assures a reliable source of chemical raw materials.

Call on us when planning current or future chemical requirements. Perhaps you can buy to better advantage from one of America's largest producers of basic industrial chemicals.

MATHIESON CHEMICALS

OLIN MATHIESON CHEMICAL CORPORATION

INDUSTRIAL CHEMICALS DIVISION · BALTIMORE 3, MD.

2761

CAUSTIC SODA · SODA ASH · CHLORINE · SULPHURIC ACID · SULPHUR · AMMONIA · NITRATE OF SODA · BICARBONATE OF SODA · NITRIC ACID · SULPHATE OF ALUMINA · SODIUM CHLORITE PRODUCTS
ETHYLENE OXIDE · ETHYLENE GLYCOL · DIETHYLENE GLYCOL · TRIETHYLENE GLYCOL · POLYGLYCOLS · DICHLOROETHYLETHER · ETHYLENE DICHLORIDE · METHANOL · SODIUM METHYLATE · ETHYLENE DIAMINE

MATHIESON

LOW MAINTENANCE
HIGH PERFORMANCE
PUMPING

"K" type pump handling concentrated mixture containing high proportion of free sulfuric acid.

HILLS-McCANNA "K" type HYDRAULIC metering and proportioning pump

In the Hills-McCanna "K" pump, a unique, in-line, direct acting hydraulic drive system eliminates familiar pump problems of exposed linkage, linkage lubrication, atmospheric effects . . . linkage and drive misalignments. Maximum reliability and performance with a minimum of maintenance is assured.

But there's more . . .

A wide choice in corrosion, wear and abrasion-resistant liquid ends gives the "K" pump a broad application range . . . it will meter and proportion virtually any fluid.

If you refine, process, handle or just *pump* problem fluids, it will pay you to remember that the Hills-McCanna "K" pump is available in one and two feed units in capacities up to 726 gph per feed.

Write for Bulletin KP54, HILLS-McCANNA CO., 2448 W. Nelson St., Chicago 18, Illinois.

COMPLETELY ENCLOSED

ADJUSTABLE WHILE IN OPERATION

OPERATES IN OIL

BUILT-IN PRESSURE RELIEF

HILLS-McCANNA

metering and proportioning pumps

Also Manufacturers of:
SAUNDERS TYPE DIAPHRAGM VALVES
FORCE FEED LUBRICATORS • LIGHT ALLOY CASTINGS

expanding mechanism forcing the shoes outward against the shell with uniform pressure over the entire area of the shoe. The design generally reduces evaporation losses at the edges of the roof and lessens the possibility of corrosion in the space housing the sealing mechanism. Wyatt Metal & Boiler Works, P. O. Box 3052, Houston, Texas.

Circle No. **16** *on Reply Card*

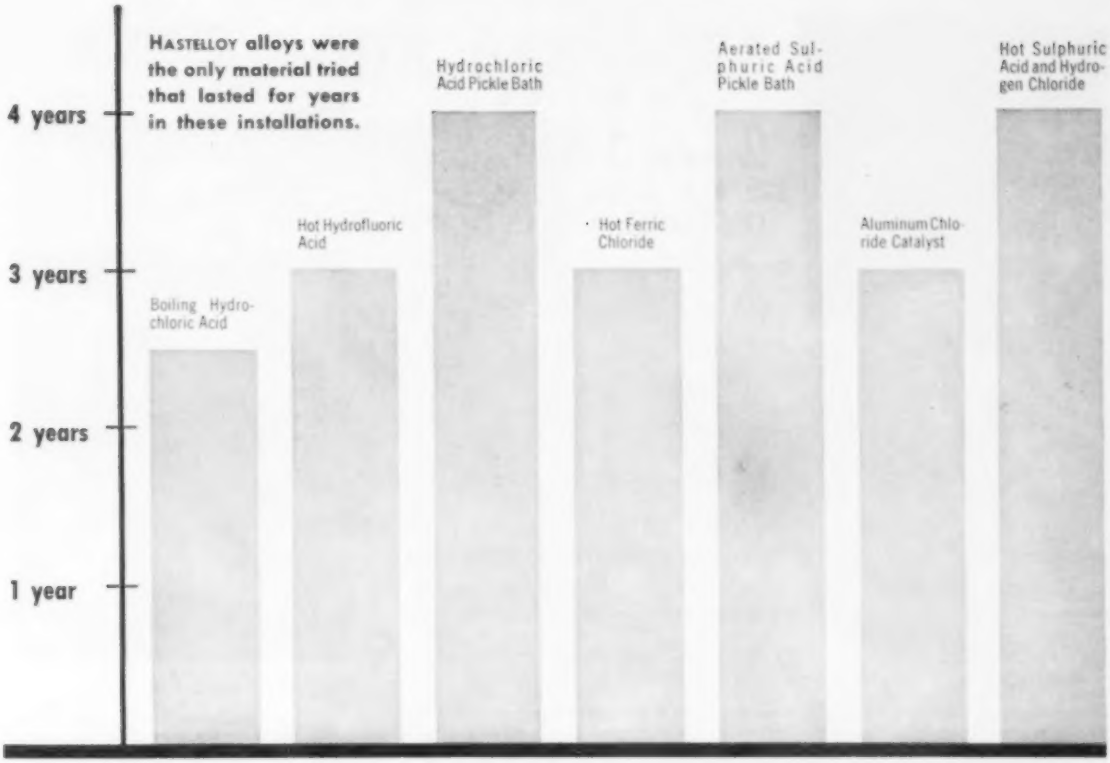
Reid Vapor Pressure Bombs

. . . **are redesigned** to feature easier assembly and disassembly, requiring no wrenches or other tools. "O"-ring gaskets can withstand temperatures from —65 to +225°F. and resist the action of gasoline, LPG and other vapors. Seven gauges are now available for the bombs, covering the entire range of pressures from 0 to 250 psi. The bombs, used for ASTM Methods D 323 "Test for Vapor Pressure of Petroleum Products (Reid Method)" and D 1267 "Test for Vapor Pressure of Liquefied Petroleum Gases," are now made of stainless steel in both the pressure and the immersion models. Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle No. **17** *on Reply Card*

Phosphorus Pentasulfide

. . . **used as an intermediate** for manufacture of thio-sulfates for oil and grease additives, ore flotation agents, insecticides and other chemicals, is now available from a new process. The pure distilled phosphorus pentasulfide, made with pure electric furnace phosphorus, is a greenish-yellow


HASTELLOY alloys were the only material tried that lasted for years in these installations.
4 years
3 years
2 years
1 year
Boiling Hydrochloric Acid
Hot Hydrofluoric Acid
Hydrochloric Acid Pickle Bath
Hot Ferric Chloride
Aerated Sulphuric Acid Pickle Bath
Aluminum Chloride Catalyst
Hot Sulphuric Acid and Hydrogen Chloride

HASTELLOY Alloys *last for years under severe corrosive conditions*

These graphs were drawn from data on actual installations of HASTELLOY alloys in severe corrosive media. No other material tried lasted more than six months in most of these installations, some considerably less than this. HASTELLOY alloys lasted for years.

Use of HASTELLOY alloys saved time, money, and production time in all the installations. The graphs do not tell the entire story by any means. Some of the parts made of HASTELLOY alloys were still going strong when the data were obtained. In some, corrosion was complicated by abrasion, impact, and the presence of contaminants.

Samples for testing HASTELLOY alloys under actual operating conditions are available without obligation. Just let us know what corrosive conditions are involved. For a copy of a booklet describing HASTELLOY alloys, get in touch with the nearest Haynes Stellite Company Office.

HAYNES TRADE MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works: Kokomo, Indiana

Sales Offices

Chicago - Cleveland - Detroit - Houston - Los Angeles - New York - San Francisco - Tulsa

"Haynes" and "Hastelloy" are registered trade-marks of Union Carbide and Carbon Corporation.

(To obtain more data on advertised products see page 1252)

NEW
Arnold O. Beckman
MODEL F3
OXYGEN ANALYZER

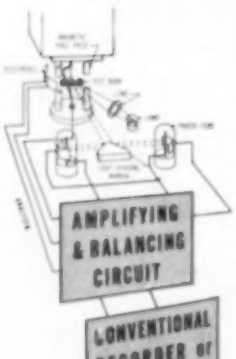
with the meter on the door

New convenience has been built into the well-known F3 Oxygen Analyzer . . . a meter on the door provides readings at the sampling point for making calibration checks, process changes, etc. In fact, complete analyzing, calibrating and indicating components are now incorporated into the single F3 unit—at no extra cost!

Use The Model F3
ON OPERATIONS LIKE THESE . . . TO MAKE SAVINGS LIKE THESE

COMBUSTION Boilers, Kilns, Direct-Fired Heaters, Stills, etc.	*Higher combustion efficiencies at lower fuel costs*
PROCESSING Air Liquifract[ion] . . . Processing Butadiene, Acetylene and Similar Gases	*Better product quality with minimum oxygen or air contamination*
PLANT SAFETY Hydrogenation, Hydrofining, Gas Compressors, Sulfur Grinding, etc.	*Control explosive atmospheres, reduce fire risks, minimize plant and personnel hazards*

Unique Operating Principle



The various applications highlighted above are only a few of the many ways Arnold O. Beckman Oxygen Analyzers—industry's great new profit builders—are being used by progressive operators to boost profits, cut costs.

These are the *only* oxygen analyzers that *continuously* measure process streams by an advanced magnetic principle that provides *direct physical measurement of the oxygen itself*—not of some secondary relationship.

Heart of the unit, as illustrated, is a dumbbell-shaped test body suspended in a magnetic field. Sample gas surrounding this test body causes it to rotate in the field, depending upon the oxygen content of the gas. The movement of a light beam, reflected by a small mirror on the test body, is measured by simple electronic circuits . . . and the result indicated directly on a conventional recorder or indicator. It's simple, positive, accurate!

No chemicals—filaments—catalysts cams—complicated mechanical parts!

FEATURES OF THE F3

Many Ranges: Full scale ranges of 0-5%, 0-10%, 0-15% O_2 and higher.
Accuracy: 1% of full scale.
Multi-Ranges: Any instrument may be supplied with two or more ranges.
Note: For ranges narrower than 0-5% O_2 ask about the Model G2.

Send for Helpful Free Literature *which describes this unique operating principle in detail—explains its many advantages and applications. When writing, outline your particular operations—we'll gladly supply specific information.*
Ask For Data File 16J-85

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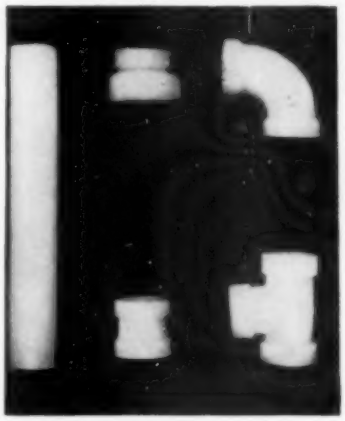
Instruments for Science and Industry
1020 MISSION STREET
SOUTH PASADENA, CALIFORNIA

See Our Booths #419-420 at the September ISA Show.

granular powder. Typical analysis is 27.9% phosphorus and 72% sulfur with a 280°F. melting point. Inorganic Chemicals Division, Monsanto Chemical Co., St. Louis 1, Mo.

Circle No. **18** *on Reply Card*



Polyethylene Fittings

. . . **are available** in threaded and sleeve lines. Each line includes elbow bends, short tees, swept tees and swept bends. The threaded line also includes a half coupler with a male thread and a half coupler with a loose nut. There is also a blanked screw cap for cleaning. A stainless steel band clamp is available for connecting sleeve fittings. The fittings are in addition to 1¾-in. O.D. polyethylene pipe made by the company, furnished in one and six foot lengths. All fittings and pipe are 1½-in. I.D. actual dimension and are interchangeable. Color is natural white polyethylene. Arthur S. LaPine & Co., 6001 Knox Ave., Chicago 29, Ill.

Circle No. **19** *on Reply Card*

Free Trade Literature

Zinc for Corrosion

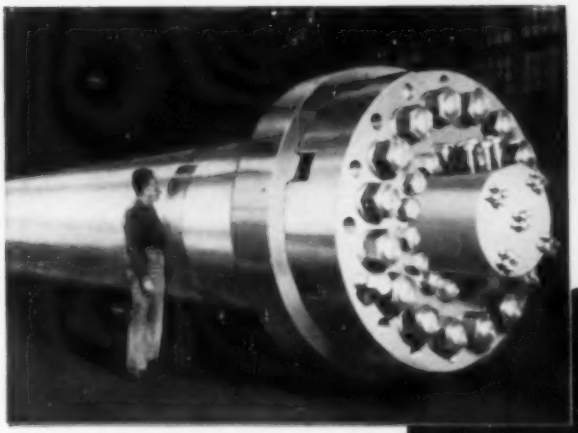
. . . control when used as coating, paint pigment or sacrificial anode: 32-page booklet *"How Zinc Controls Corrosion,"* tells how zinc may be applied in numerous cases. American Zinc Institute, 60 E. 42nd St., New York 17.

Circle No. **20** *on Reply Card*

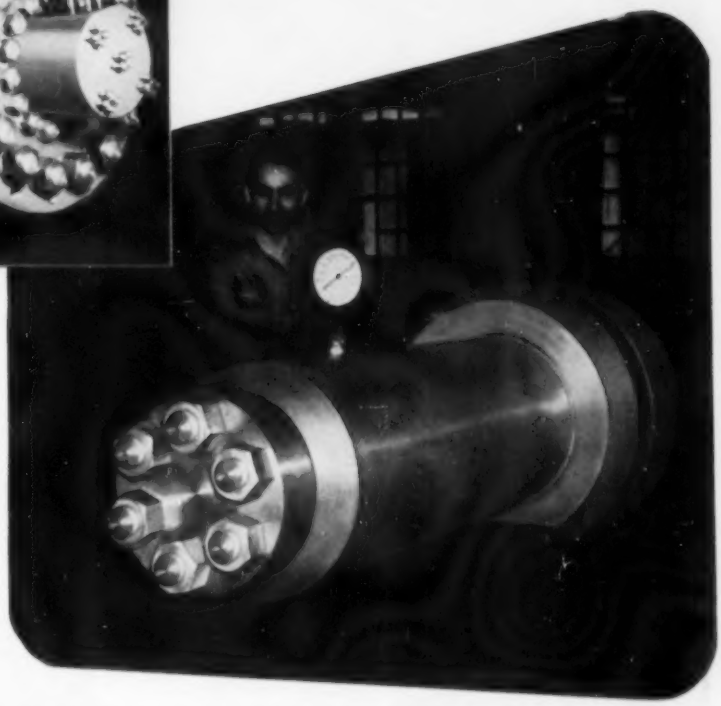
Viny! Lining for Concrete

. . . pipe and other structures, imbedded in concrete at pouring, gives members strength and resistance to age, abrasion, acids, alkalies and other corrosives: bulletin on *"T-Lock Amer-*

WHAT'S YOUR PRESSURE PROBLEM?



4,000 PSI CONVERTER



40,000 PSI CYLINDER

MIDVALE FORGES VESSELS TO YOUR SPECIFICATIONS

These pressure vessels are just two examples of the wide adaptability of Midvale facilities to forge and machine pressure vessels to your specifications. One was a big brute of chrome-vanadium steel with an overall length of 468″, inside diameter of 45″ and outside diameter of 61½″ . . . with a working pressure of 4,500 PSI. The other only 102″ in length, inside diameter of 10″ and outside diameter of 22″ . . . but was tested to 40,000 PSI.

Both varied greatly in the equipment necessary and the production procedure used, but the same engineering and forging experience—gained over more than half a century—solved the problem of each. The quality of both was carefully guarded from the time the ingot was poured until final machining. Physical testing and careful inspection assured pressure vessels to give long service in the installation specified.

Next time your plans include vessels for the production of chemicals, petroleum, rubber or other products call on Midvale engineers. Their experience with forged vessels will help you from the initial design to the final installation.

THE MIDVALE COMPANY- Nicetown, Philadelphia 40, Pa.

Offices: New York, Chicago, Pittsburgh, Washington, Cleveland, San Francisco

MIDVALE

FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

GLITSCH
LARGE...
OR SMALL . . .
TRAYS
Simple and adaptable in design, GLITSCH "Truss-Type" lightweight trays can be designed for any process requirement with respect to tray size, process layout, type of flow, type and shape of downcomer, weirs, wells, and size and shape bubble caps as well as suitable corrosion resistant materials.
GLITSCH BUBBLE CAPS
Dies for 287 different cap and riser assemblies are now available. The cap styles can be varied further by a wide range of slots. Holddown styles simplify clean-outs, reduce "off-stream" time to a minimum.
Glitsch
FRITZ W. GLITSCH & SONS, INC.
P. O. Box 6227
DALLAS 3, TEXAS
Your engineering staff can effect definite savings in initial designing by utilizing GLITSCH world-wide experience in plans, design and fabrication of tower internals. Cost analyses are available promptly.
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New York City residents, add 3% city sales tax

Plate" gives properties, shows applications. Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.

Circle No. **21** *on Reply Card*

Water Pollution Abatement

. . . in oil and tar discharges: *Manual Sheet W-4*, part of a series on water pollution, covers permissible concentrations and removal techniques, and has diagrams of API separator, air induced flotation method, and hay filter installation. Manufacturing Chemists' Association, 1625 Eye St., N. W., Washington 6, D. C.

Circle No. **22** *on Reply Card*

Spectrophotometer

. . . infrared, automatic, with high accuracy afforded by use of linear amplifier and potentiometer recorder: *Bulletin 410* describes certain special features, gives sample spectrums of polystyrene and p-xylene. Beckman Instruments, Inc., Fullerton, Calif.

Circle No. **23** *on Reply Card*

General Technical Data

. . . used in a variety of fields are compiled in this 112-page paper-bound volume; in chemistry and physics "*Tables and Data*" has conversion tables, equivalents, weights and measures; in engineering there are physical properties of metals, hardness scales, dielectric characteristics, etc. Write on company letterhead to H. M. Block, United States Testing Co., 1415 Park Ave., Hoboken, N. J.

(Do Not Use Reply Card)

Plastic Products

. . . in a modified polyvinyl alcohol resin known as "Compar" which is not affected by any water insoluble liquids: bulletin discusses outstanding characteristics, physical properties, permeability to gases, and some products. Resistoflex Corp., Belleville 9, N. J.

Circle No. **24** *on Reply Card*

Safety Switches

. . . used in oil and irrigation industries: new catalog contains information about full line of switches, including prices, specifications, diagrams. Frank W. Murphy Mfr., P. O. Box 1476, Tulsa, Okla.

Circle No. **25** *on Reply Card*

High-Strength Steels

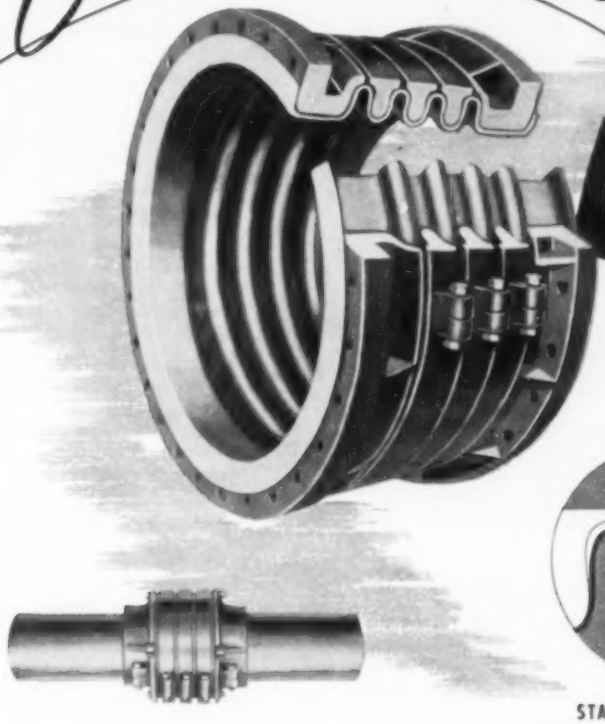
. . . handbook for the engineer: 174-page *Design Manual for High-Strength Steels*, by U. S. Steel's H. Malcom Priest, contains charts and formulas

BADGER *Expansion Joints*

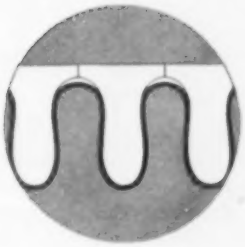
Typifying Expansion Joint Engineering At its Best

Controlled Movements

through DIRECTED FLEXING



STARTING POSITION
(LINE COLD)



FINAL POSITION
(FULL TEMPERATURE)

With the old style corrugations, there was little control over the flexing movement. Our engineers long ago found this to be a major cause of uncertain joint life and set about to solve the problem.

Directed Flexing, based on a scientifically engineered design of all-curve corrugation, solved the problem. That was some years ago. Notwithstanding continual further studies, nothing anywhere has supplanted Directed Flexing as a major design factor in long joint life. It's another example of what engineering has done to make the Badger Expansion Joint "tops" in its field.

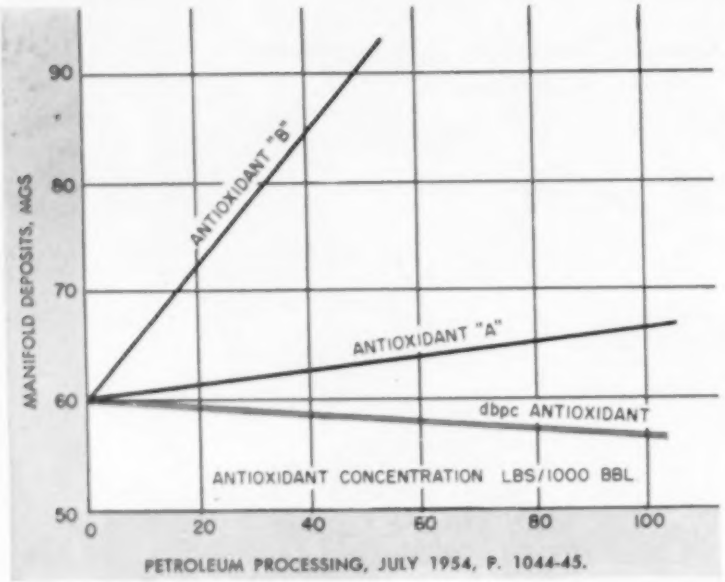
Badger Expansion Joints come in a variety of types and a wide range of sizes: Directed Flexing, Self-Equalizing for normal and long traverses and higher pressures; Non-Equalizing, for short traverse or when pressures are low; Tandem Joints for combination axial and lateral movements; Clevis-Hinged Joints for angular movements; Flexible Pipe Line Seals for watertight connections between pipes and flood walls.

BADGER MANUFACTURING COMPANY

Original and Sole Manufacturer of Badger Expansion Joints

230 BENT STREET • CAMBRIDGE • MASS.

Engine Tests prove . . .



PETROLEUM PROCESSING, JULY 1954, P. 1044-45.

dbpc Antioxidant contributes NO manifold deposits

Three antioxidants were tested in a blend containing 60% catalytic cracked and 40% thermal cracked gasolines. The antioxidants tested were **dbpc**[*] inhibitor[*] and antioxidants "A" and "B" — other well-known commercial gasoline gum inhibitors.

The manifold test unit consisted of a specially-designed manifold attached to a single-cylinder, air-cooled engine, with provisions for control of fuel rate and temperature. The air-fuel mixture from the carburetor entered the manifold which was heated by two 500-watt, pancake electric heaters attached to the manifold exterior. Manifold temperature averaged 255° F.

dbpc (indicated in red) did not contribute to manifold deposits. Actually, it tended to *reduce* deposits. Antioxidants "A" and "B" however, *increased* manifold deposits.

dbpc is safe and easy to handle. It is economical, highly soluble in gasoline and is inert to extraction by caustic and water and the commonly used pipe corrosion inhibitor.

dbpc is also supplied in easy to handle liquid form as Impruvol 33[®] antioxidant.

For full information write:

[*]2, 6 di-tert-butyl-para-cresol

KOPPERS COMPANY, INC.
Chemical Division, Dept. PP-85, Pittsburgh 19, Pennsylvania

Koppers Chemicals

KOPPERS ®

SALES OFFICES: NEW YORK · BOSTON · PHILADELPHIA · ATLANTA
CHICAGO · DETROIT · HOUSTON · LOS ANGELES

for structural carbon steel as well, and an entire section is about designing against corrosion. For information about availability write to U. S. Steel Corp., 525 William Penn Pl., Pittsburgh, referring to publication ADVL-215-54.

(Do Not Use Reply Card)

Flaw Location

. . . with dye penetrants; 16 mm. color and sound motion picture, available for free showing, shows dye penetrant inspections from laboratory theory to production line and includes actual inspections of oil tool components and pressure vessel weld seams. For information about the film: Turco Products, Inc., 6135 South Central Ave., Los Angeles 1, Calif.

(Do Not Use Reply Card)

D-P Transmitter

. . . uses a Barton flowmeter as the measuring element for a Moore motion transmitter: *Bulletin 1102* has cross-sections, dimensions, performance data, and design specifications of both units. Moore Products Co., H. & Lycoming Streets, Philadelphia 24.

Circle No. **26** *on Reply Card*

Protective Coatings

. . . compared as to properties: "*Comparative Properties of Protective Coatings*," a 19-page report by Gerald F. Gilbert, Jr., to the National Association of Corrosion Engineers, treats 14 types of coatings, giving physical and chemical data, value of the coatings against weather, impact, abrasion, heat, water and various kinds of chemical attack. Atlas Mineral Products Co., Mertztown, Pa.

Circle No. **27** *on Reply Card*

New pH Indicator

. . . with four millivolt ranges for redox work, Karl Fischer titrations and other dead-stop, end-point measurements as well: *Data Sheet E-96(2)* gives specifications, list of mountings and electrodes for redox and pH measurements, and accessories. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44.

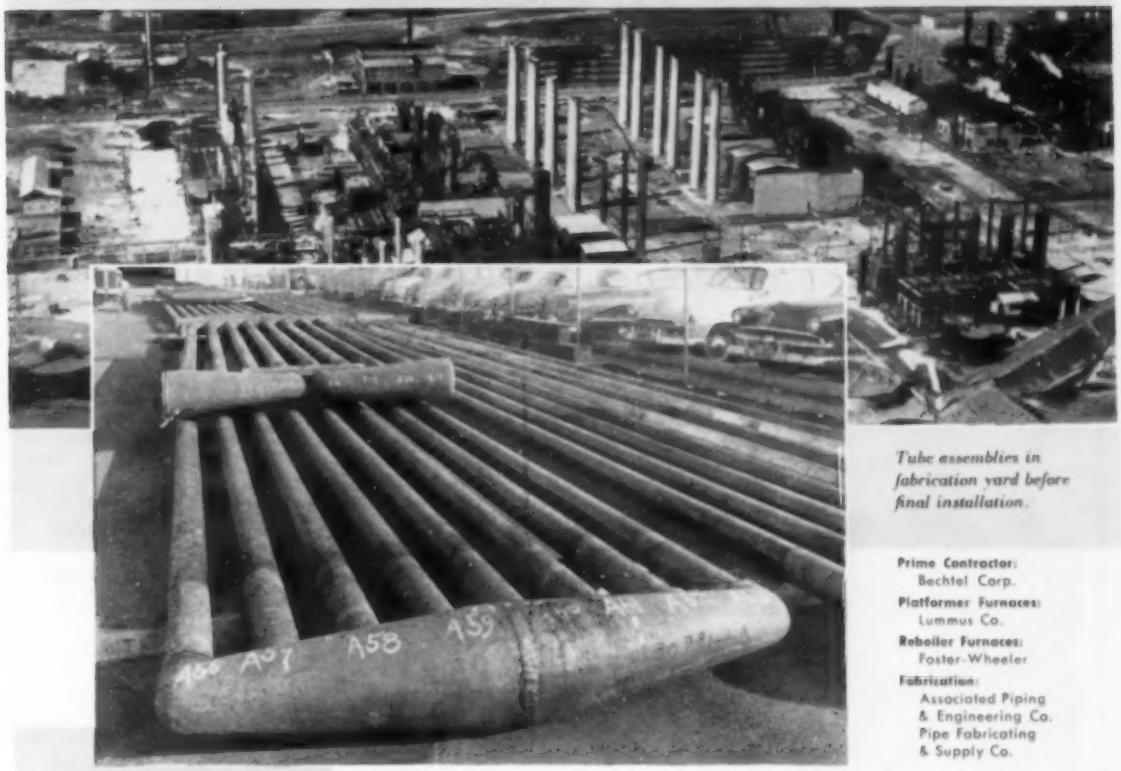
Circle No. **28** *on Reply Card*

All About Amines

. . . including older and newer reactions, physical and chemical properties, and a long list of applications from the company's experience and the literature: 52-page "*Sharples Amines*." Sharples Chemical Division,

KEY-KAST® FITTINGS

on Fabrication Assemblies for Platforming Charge Reheaters and Reboilers of Standard Oil Company of Calif.



Tube assemblies in fabrication yard before final installation.

Prime Contractor:
Bechtel Corp.

Platformer Furnaces:
Lummus Co.

Reboiler Furnaces:
Foster-Wheeler

Fabrication:
Associated Piping & Engineering Co.
Pipe Fabricating & Supply Co.

JOB DETAILS:

Tube size:	**6⅝" O.D. x .675" minimum wall**
Material:	**2¼ % chrome, 1% molybdenum**
Designed for: Pressure-temperature:	**830 lb., 1125°F.**

These specially-designed Key-Kast multiple-hole fittings were produced by Key Co. for installation in the new catalytic reformer units at Standard Oil Company of California's refineries at El Segundo (illustrated) and Richmond.

More and more refineries, in fact, are finding Key-Kast fittings and flanges the answer to their alloy piping needs. . . for these Key-Kast advantages mean greater structural strength and longer life:

- Greater wall thickness throughout
- Greater allowance for corrosion, with extra thickness at critical areas
- Controlled quality, through rigid metallurgical control

Key company

Since 1916 . . . manufacturers and developers of products for high temperatures and pressures

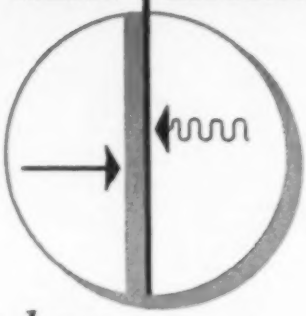
Box 494-H, EAST ST. LOUIS, ILLINOIS

DISTRICT OFFICES: NEW YORK • CLEVELAND
CHICAGO • TULSA • HOUSTON • LOS ANGELES

(To obtain more data on advertised products see page 1252)

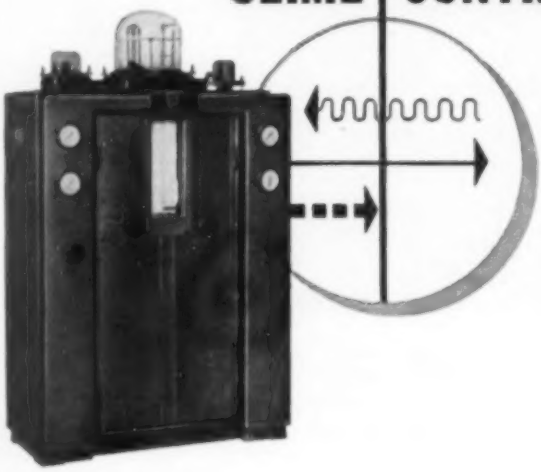
Where you need

HEAT | EXCHANGE



Be sure you have

SLIME | CONTROL



• Whether you heat or cool water for make-up, process or any other use, you will need Wallace & Tiernan Chlorination to help combat slime problems introduced by water-borne bacteria or air-borne bacteria.

With slime control equipment designed for any need, built for lasting and dependable service, highly accurate and backed by over 40 years of successful application experience, Wallace & Tiernan Chlorination can help you increase the efficiency of your plant and cut operating costs. For further information write our Industrial Division.

WALLACE & TIERNAN

25 MAIN ST., BELLEVILLE 9, N. J.

CHLORINATORS • CHEMICAL FEEDERS • SCREENING EQUIPMENT • MAGNETIC SEPARATORS • PRECISION PRESSURE INSTRUMENTS • CATHODIC PROTECTION • FINE CHEMICALS

CD-39

Pennsylvania Salt Mfg. Co., Three Penn Center Plaza, Philadelphia 2.

Circle No. **29** *on Reply Card*

New Polyethylene

. . . material, trade-named "Hypalon," a chlorosulfonated polyethylene: *"Facts About Hypalon"* will be released periodically in notebook form, and first issue describes some of its outstanding attributes. Published by Elastomers Division of the Du Pont Co., Wilmington, Del.

Circle No. **30** *on Reply Card*

Flocculating Reagents

. . . synthetic polymers that will settle finely divided solids in an aqueous medium and thus aid filtration: bulletin on *"Aerofloc Reagents"* tells about the feeding technique, applications, how to test for effectiveness, and which reagents are available. American Cyanamid Co., Mineral Dressing Dept., 30 Rockefeller Plaza, N.Y.C.

Circle No. **31** *on Reply Card*

Finned Exchanger Tubes

. . . with fins of stainless clad copper, the company's answer to the problem of overheated fin-tips: *G-R News*, Spring edition, tells of fin's development, compares performance with fins of carbon steel and stainless steel. Griscom-Russell Co., Massillon, Ohio.

Circle No. **32** *on Reply Card*

Current Controller

. . . a pneumatic-electric transducer which regulates voltage, current, resistance, inductance, and capacitance, using autotransformers, rheostats, and potentiometers: *Bulletin EB-1* has application diagrams, dimensions, and specs. Conoflow Corp., 2100 Arch St., Philadelphia 3, Pa.

Circle No. **33** *on Reply Card*

Corrosion-Resistant Alloys

. . . in tubing and pipe; nickel-molybdenum for halogen acid service, and nickel - molybdenum - chromium for strong oxidizing conditions: bulletin on alloys "B" and "C" contains list of properties, information about workability and applications. Carpenter Steel Co., Alloy Tube Division, Union, N. J.

Circle No. **34** *on Reply Card*

Gradiation Heating

. . . in petroleum and chemical processing: *Bulletin S-1043* discusses applications, operating principles, features of construction and design, and

From Regina to Saudi Arabia

B-L VESSEL LININGS SET RECORD AFTER RECORD FOR DEPENDABLE PERFORMANCE

It looks like a Cook's Tour—but it isn't. Instead it's a listing of recent Bigelow-Liptak refinery installations in far-flung corners of the world.

There are good, solid reasons for this world-wide preference for Bigelow-Liptak jobs. In the first place from B-L's years of experience has come a *complete castable package*. Insulating- and abrasion-resistant castables are *engineered, furnished* and *installed* by the same company—which means just one contract and one responsibility.

The overall result of this all-in-one engineering is exceptional durability and performance. B-L refractory installations have established world records for continuous operation. For example, after initial runs of 785 and 610 days, B-L linings were in perfect shape—required no repairs during shutdowns.

Yes, from Regina to Saudi Arabia—and points in between—Bigelow-Liptak installations are setting new records for service and performance. For complete information write for the B-L catalog "One Source". Do it today!

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Regina, Canada	Regenerator and Cyclones
Batangas, Philippines	Regenerator and Cyclones
Yokohama, Japan	Regenerator and Cyclones
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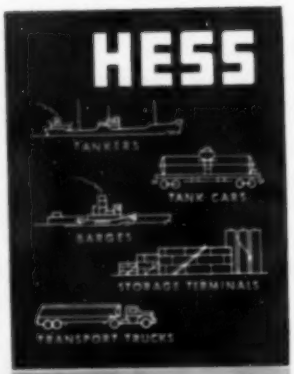

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VAlley 6-1000

HESS TERMINAL CORP.
Houston, Texas
Glendale 37195

some low-capacity heaters. Selas Corp. of America, Philadelphia 34, Pa.

Circle No. **35** *on Reply Card*

Controlled Volume Pump

. . . for accurate chemical feed of non-corrosive or mildly corrosive liquids at normal temperatures: *Bulletin H20-1* gives special features, dimensions, and specifications of the H-20 model pump. Milton Roy Co., Station H, 1300 East Mermaid Lane, Philadelphia 18, Pa.

Circle No. **36** *on Reply Card*

Teflon Products

. . . are discussed in three new bulletins: *CP552*, on packings and a patented seal cage, *CP553*, on gaskets and expansion joints, and *CP554*, on special molded and machined parts, and glass, carbon and zircon-filled Teflon. Chemical and Power Products, 11 Broadway, New York 4, N. Y.

Circle No. **37** *on Reply Card*

Infrared Analyzers

. . . of four main types in the "Tri-Non" line, varying in complexity of design: bulletin gives applications of each type, characteristics, performance, and complete specifications. Perkin-Elmer Corp., Norwalk, Conn.

Circle No. **38** *on Reply Card*

Mass Spectrometer

. . . for liquid and gas analysis in refinery streams, chemical reaction processes, absorption techniques, etc.: 15-page *Bulletin 1800C* describes principles of operation of the model "21-103C," applications, description of components, operating features, analysis procedure, company services to the user, and accessories. Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle No. **39** *on Reply Card*

Lubricated Plug Valves

. . . for process control: *Form No. 1003* describes plug valve construction and operation, giving general dimensions, catalog number, types of lubricants to use for different liquid services and lubrication specifications and functions. The Ohio Injector Co., Wadsworth, Ohio.

Circle No. **40** *on Reply Card*

Continuous Mass Spec

. . . for quality control in plant operations for petroleum, chemical, and gas industries: 11-page *Bulletin CEC-*

high quality product

boost average ratings as much as 2 octane numbers with the

Ljungstrom® Air Preheater

With waste heat recovered and returned to the furnace in combustion air, the most modern heat-transfer systems can be operated at peak efficiency.

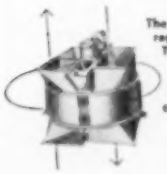
That's why you boost product quality with the Ljungstrom Air Preheater. It's heat-recovery efficiency makes possible advanced furnace designs that assure remarkably close control of processing. And finer control means a more uniform product . . . with average ratings as much as 2 octane numbers higher. One still's added income just from higher product quality is $58,000 annually.

HOW FAST IS "WRITE-OFF"?

in earnings from higher octane ratings, many refiners write off the cost of the Ljungstrom installation in less than two years. This time is cut to *nine months and even less*, when the other Ljungstrom advantages are taken into account — saves up to 20% in fuel costs . . . permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat recovery benefits obtainable in fuel burning equipment — call or write The Air Preheater Corporation.

Wherever You Burn Fuel, You Need Ljungstrom



The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transfered from the waste gases to the incoming cold air.

The Air Preheater Corporation 60 East 42nd Street, New York 17, N. Y.

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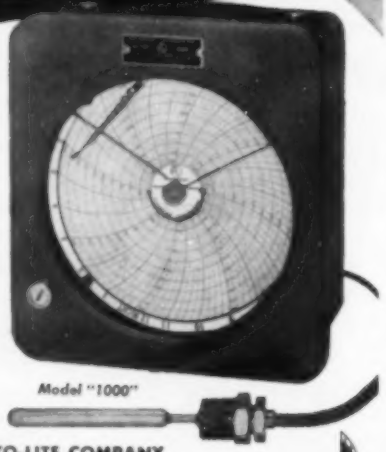
Send for new catalog describing many styles of Auto-Lite temperature Recorders and Indicators.



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TEMPERATURE RECORDERS

What's New!

1824A describes how the mass spectrometer works, its use in process monitoring and control, the basic instrument and accessories, applications, performance characteristics, ordering information—and price list inserts. Consolidated Engineering Corp., 285 Madison Ave., New York 17, N.Y.

Circle No. **41** *on Reply Card*

Motor Buying Information

. . . for standard a-c fractional and integral horsepower motors: 28-page *Catalog GEC-1026* covers selection of motors including horsepower requirements, enclosures, starting current limitations, speeds, motor types, selection of fuses and circuit breakers for single-phase, polyphase, totally enclosed fan cooled, and gear-types with information on ratings, book prices, dimensions, weights, etc. General Electric, Schenectady 5, N. Y.

Circle No. **42** *on Reply Card*

Dye Flaw Location

. . . on any metal surface: 12-page booklet *Flaw Location by Dye Penetration* describes the use of dye penetrants, where they can be used, field and plant applications, how to apply, and advantages. Turco Products, Inc., 6135 South Central Ave., Los Angeles 1, Calif.

Circle No. **43** *on Reply Card*

Oscillogram Processor

. . . for on-the-spot developing of photographic oscillograph records: *Bulletin 1537C* describes the portable "darkroom," its operation, size and capacity, and includes a price list insert. Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle No. **44** *on Reply Card*

Residual Cl_2 Analyzer

. . . for continuous determination of free residual chlorine in chlorinated water and functioning on the coulometric principle: *Data Sheet ND46-94(1)* describes equipment, operation, specifications, etc. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Circle No. **45** *on Reply Card*

Solderless Terminals

. . . for maintenance and repair of wiring devices: 26-page catalog lists all commonly used terminals, connectors and application tools with almost 500 terminals and connectors and custom tailored wiring kits. Amer-

FILTER CLOGGING

IS A DOUBLE-BARRELED PROBLEM TOO-

Filter and screen clogging is the result of a double-barreled problem: insoluble colloidal oxidation products derived from the fuel oil itself and corrosion debris from storage tanks. To obtain a complete solution, it is absolutely essential that both types of clogging materials be eliminated.

With Driacin you can be certain of the necessary double-barreled action. Driacin completely solves the first problem by stabilizing the growth of colloidal oxidation particles at a size so small they will easily pass through oil filters and screens. In addition, Driacin contains a remarkable new corrosion inhibitor which will simultaneously eliminate all but traces of rusting in your storage tanks.

It is this dual action which is necessary for the complete elimination of your clogging problems and differentiates Driacin from the ordinary detergent additives which do not prevent rusting, but cause additional filter clogging by dislodging rust and slime from tank walls.

Although organic oxidation products form less readily in straight-run fuels, rusting does occur and many fouling problems in pot-type burners can result from iron corrosion products. By eliminating this type of deposit, Driacin will improve the functioning of pot-type burners.

Use **DRIACIN** *and protect your fuel and your tanks*

Use **DRIACIN** *and protect your customers' burners*

PRODUCTS DEPARTMENT
UNIVERSAL OIL PRODUCTS COMPANY

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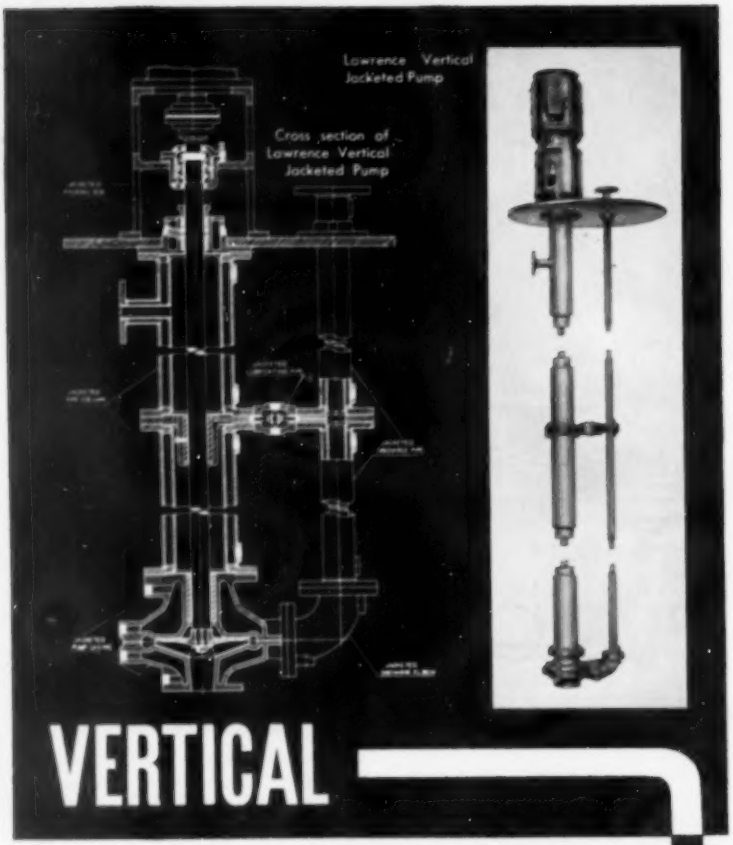


VERTICAL

jacketed PUMPS

Lawrence vertical jacketed pumps are designed to pump liquids such as sulphur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. The heating medium can be steam, dowtherm, etc.

The pump is jacketed throughout, i.e. — the pump casing, pipe column, discharge pipe and packing box. All heating spaces are vented and self-draining.

For submerged operation, these pumps are frequently made with only the pipe column, discharge pipe and packing box jacketed; the pump itself, not being jacketed.

If you have to pump liquids which must be maintained above a certain temperature to prevent solidification, write us the pertinent details. No obligation.

Write for Bulletin 203-7.

LAWRENCE PUMPS INC.
361 Market Street, Lawrence, Mass.

ican Pamcor, Inc., 181 Hillcrest Ave., Havertown, Pa.

Circle No. **46** *on Reply Card*

Piping Flexibility Tips

. . . for the petroleum industry: *Bulletin No. 28, How to Solve Piping Flexibility Problems* describes use of flexible ball, swing, swivel, revolving and other types of movable joints. Barco Mfg. Co., Dept. R25, 501 Hough St., Barrington, Ill.

Circle No. **47** *on Reply Card*

Propylene Glycol

. . . for petrochemical intermediates and other uses: 16-page *Data Folder (F-8738)* gives data on physical and physiological properties, specifications, shipping containers, constant-boiling mixtures, solubilities, and applications. Carbide and Carbon Chemicals Co., 30 E. 42nd St., New York 17, N.Y.

Circle No. **48** *on Reply Card*

Designing Water Clarifiers

. . . and cold process softeners is discussed in *Technical Reprint T-135* by V. J. Calise: principles of seeding, equations in designing, operating results, diagrams and illustrations are given. Graver Water Conditioning Co., 216 W. 14th St., New York 11, N. Y.

Circle No. **49** *on Reply Card*

Heat Exchangers

. . . shell and tube, telescopic pipeline type, atmospheric sections, reboilers: booklet gives full story of company's heat exchanger operations, including economics of the different types. Western Supply Co., P. O. Box 1888, Tulsa, Okla.

Circle No. **50** *on Reply Card*

Centrifugal Pumps

. . . of single-stage, double-suction design, built to handle high static heads: *Bulletin 350-27* gives specifications and performance data on pumps from 85 to 4500 gpm. and maximum heads up to 195 ft. American-Marsh Pumps, Inc., Battle Creek, Mich.

Circle No. **51** *on Reply Card*

Air and Gas Dryers

. . . for elimination of moisture problems by dehydration: *Bulletin No. 16.0.081* describes the "Hydryers," giving method of operation and reac-

Have Fun...

Vacation time!

And where do vacations come from? They come from brick! Yes, refractory brick.

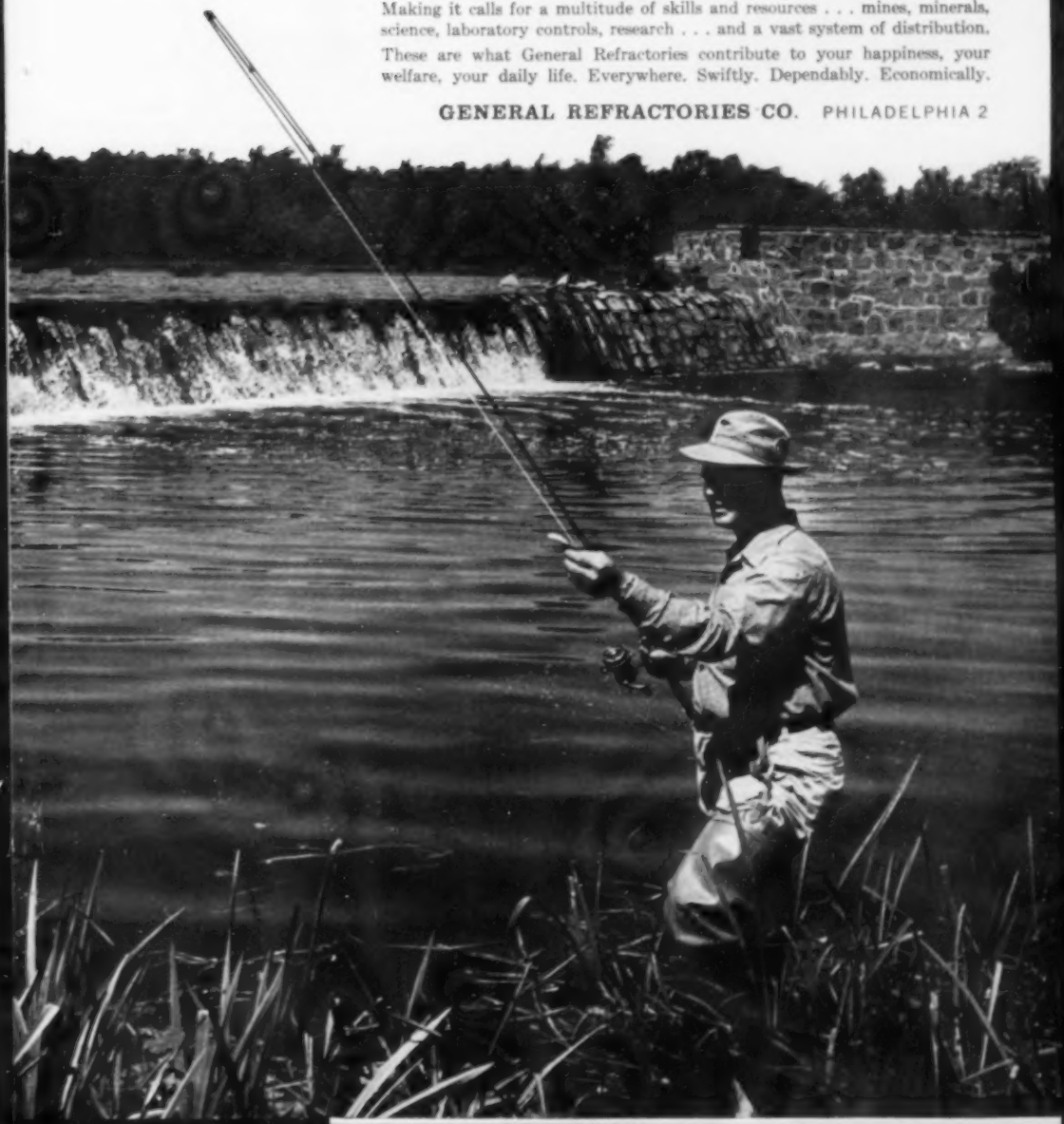
The brick that lines the furnaces of industry . . . contains their heat . . . produces the steel for that hook on the end of your line and the glass rod that holds it. Your waders, too.

Behind everything that's made lies refractory brick.

Making it calls for a multitude of skills and resources . . . mines, minerals, science, laboratory controls, research . . . and a vast system of distribution.

These are what General Refractories contribute to your happiness, your welfare, your daily life. Everywhere. Swiftly. Dependably. Economically.

GENERAL REFRACTORIES CO. PHILADELPHIA 2



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HIGH-STRENGTH BRIK-CAST—A hydraulic setting clay base castable having exceptionally high strength. Available in regular, pneumatic gun mix and trowel mix.

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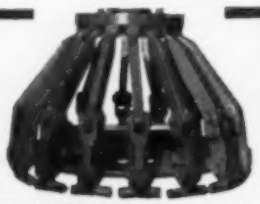

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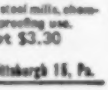

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tivation, and discusses operating cycle length, adsorbents, unit sizes, construction, controls, etc. J. F. Pritchard & Co. of Calif., 4625 Roanoke Parkway, Kansas City 12, Missouri.

Circle No. **52** *on Reply Card*

Dispersion Mixers

. . . for application to liquid-liquid, liquid-solid or gas-liquid systems: *Bulletin No. 400* describes the "Stratco Contactor," its method of operation, process applications, and physical data with illustrations. Stratford Engineering Co., Kansas City, Missouri.

Circle No. **53** *on Reply Card*

Did You Miss These?

The following items, reviewed originally in May, have aroused considerable interest among the readers. They are repeated briefly as a service to those who might have missed them the first time they appeared. For details or literature, please use the regular Reply Card in this issue.

Fin-Tube Heat Exchanger

. . . with dual pipe construction is a new line for the petroleum, petrochemical and chemical industries, and is being produced by the American Locomotive Co. ALCO has purchased the entire fin-tube business of Carter Craft, including all inventions, know-how, and equipment, and plans to produce tubes large enough to meet foreseeable market needs.

Prior to the ALCO acquisition, the fin-tube heat exchanger was produced by Carter Craft principally for equipment installed in the Hanford, Wash., Atomic Energy Commission plant.

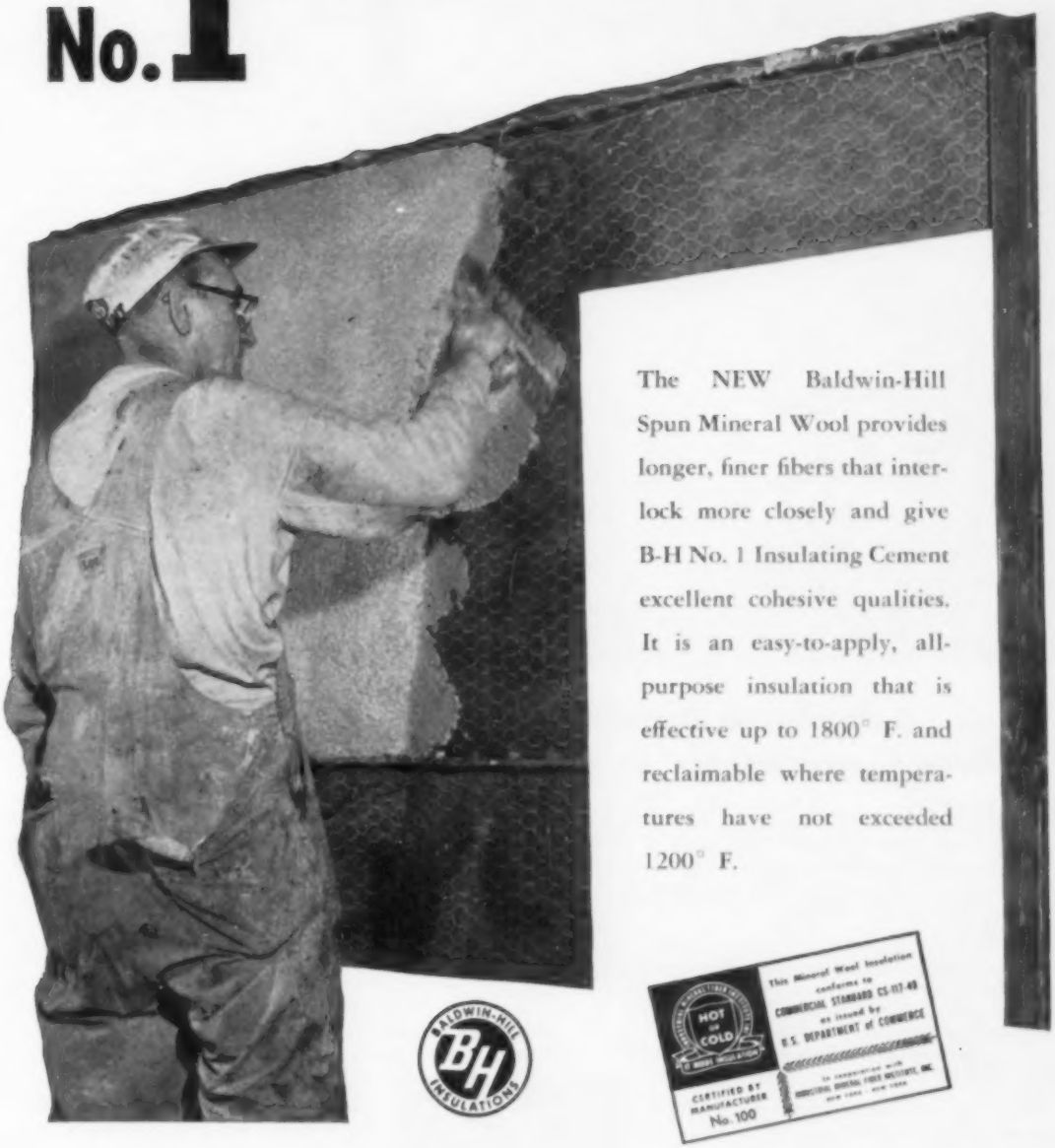
The new fin-tube heat exchanger sections consist of a double-pipe arrangement designed to give service where conventional bare-tube heat exchange is unsuited, or where the fluid being heated or cooled has an appreciably higher resistance to the exchange of heat than the fluid used for heating or cooling. The sections will be offered in a variety of sizes, lengths, materials and pressure ratings.

Tubes from individual units may be withdrawn without displacing the connecting pipe—even when units are installed in banks with interconnecting piping. Removal is made possible by

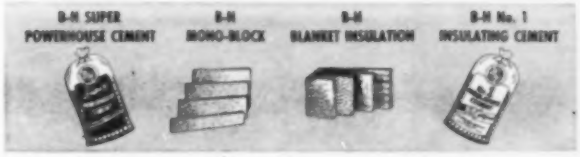
Holds together better than ever . . .

BALDWIN-HILL

No. 1 INSULATING CEMENT



The NEW Baldwin-Hill Spun Mineral Wool provides longer, finer fibers that interlock more closely and give B-H No. 1 Insulating Cement excellent cohesive qualities. It is an easy-to-apply, all-purpose insulation that is effective up to 1800° F. and reclaimable where temperatures have not exceeded 1200° F.



BALDWIN-HILL COMPANY

1608 Breunig Ave. Trenton 2, N. J.

Kalamazoo, Mich Huntington, Ind. Temple, Texas

Lube Oil Additive performance verified by actual field tests

Pistons from field tests in 8-cylinder Diesel engines engaged in continuous high-load pumping service. Piston at left (625 hours, HD oil) shows severe ring sticking and high wear. Piston on right (1,582 hours, properly compounded oil) shows no ring sticking, low wear.

Ask about Oronite's "custom-formulation" to your needs

There is no substitute for field testing. At Oronite, laboratory engine tests are made to establish compounding levels required for various field conditions. These tests are then correlated with actual field operating conditions to verify performance of the compounded oil.

Oronite specializes in "custom-formulating" additives to your exact needs—meeting your price and performance specifications. Because of Oronite's advanced research program, elaborate testing and manufacturing facilities, Oronite's "custom-compounding" packs more into your oil at a given treating cost.

Why not talk over your problems with an Oronite additive specialist. Contact our office nearest you.

With Oronite Additives you can formulate oils to meet the new A.P.I. Service Classifications and can meet specifications for 2-104-B, MIL-O-2104, Supplement I and Series 2 oils.

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20 North Wacker Drive, Chicago 6, Illinois
714 W. Olympic Blvd., Los Angeles 15, California
Mercantile Securities Building, Dallas 1, Texas
Carew Tower, Cincinnati 2, Ohio

ORONITE CHEMICAL COMPANY

elimination of the split ring at the tube-to-shell joint. American Locomotive Co., Schenectady 5, N. Y.

Circle No. **54** *on Reply Card*

Hydraulic Slide Rule

. . . calculates product pipeline operations giving conservative results for capacities and pressures. Any person familiar with slide rule operations can determine—within the accuracy of a 10-in. slide rule—the flow rate, pressure, diameter, or friction factor of the Williams and Hazen formula. Based on this formula for water flow, the rule scaling has been adapted for the specific gravity of gasoline. A viscosity factor is incorporated in the rule wherein the friction factor can be changed to correspond to the kinematic viscosity of materials other than gasoline. An instruction manual accompanies the slide rule. The rule—invented by Frank E. Richardson, consulting engineer—is made from alloy metal by Pickett and Eckel, Inc., of Calif. For information write Frank E. Richardson, Box 1612, Shreveport, La., or . . .

Circle No. **55** *on Reply Card*

Control Valve Sizing

. . . manual for steam, liquid, and gas services: 24-page *Controls Sizing Manual* includes graphs and tables of steam enthalpy-volume, flow rates, valve coefficients, and molecular weights as related to type of valve. Black, Sivalls & Bryson, Inc., 7500 E. 12th St., Kansas City 26, Mo.

Circle No. **56** *on Reply Card*

Asphalt Additives

. . . and their functions for those concerned with asphalt marketing, handling and storage: reprint of paper presented at annual meeting of The Association of Asphalt Paving Technologists covers coating of dry and wet aggregates, decreasing the surface tension, chemical composition of surfactants, and the effect of heat on additives. Carlisle Chemical Works, Inc., Reading, Ohio.

Circle No. **57** *on Reply Card*

Valve Comparison Chart

. . . lists valves of 11 different manufacturers which are equivalent in application: 17-page *Comparison Chart* is for bronze and iron-body valves, notes major differences in construction, and is organized by manufacturers and in numerical sequence. The Fairbanks Co., 393 LaFayette St., New York 3, N. Y.

Circle No. **58** *on Reply Card*

(To obtain more data on advertised products see page 1252)

HERE'S HELP

for your engineer-recruitment problem

Engineers' Joint Council and The Advertising Council offer free, expert help to advertisers promoting engineering as a career.

The booklet reproduced here was prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you make your advertising work most effectively in recruiting engineers for the future.

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2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
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Gentlemen: Please send me a *free* copy of *"How your company can help promote engineering as a career."*

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Briefly, this ad illustrates why DEMPSTER-DUMPSTER SYSTEM

Container at right has cast iron bottom and inside walls are lined with fire brick. It handles hot skim off aluminum.

This Tilt Type Container was the result of a cost-cutting idea whereby a high temperature dusty product would be handled by a plant's Dempster-Dumpster. Container has cooling fins, counter-balanced hinged lid with 3-way locking device, 16" sliding gate valve and two sight-glass inspection openings.

Here is a Hopper Type Container with a top door for filling and two bottom discharge doors operated by rack and pinion. Another case where the Dempster-Dumpster System was applied to an additional problem to further reduce costs.

Container at right is just one of several different types we have designed to handle equipment, materials, packages, parcels, etc.

IN A NORMAL INSTALLATION the Dempster-Dumpster System is purchased by a plant because of its proved record for handling bulk materials at tremendous savings. This normal installation usually includes one truck mounted Dempster-Dumpster and any number of standard containers designed to meet the various requirements within the plant. In some cases, containers number 40 to 50. These containers can range in capacity up to 21 cu. yds., with all containers served by the one Dempster-Dumpster.

In the great majority of cases this basic installation is just a starter. Management men, constantly looking for lower operating costs, find numerous and amazing extra savings in the Dempster-Dumpster System. Once in service, transporting developments of every description come to light that supplement the original functions of the equipment. Your own men find easier, quicker and additional cost saving ideas for its use. Many even overshadow the original savings and the equipment becomes more and more indispensable.

Look over just a few of the "Special" containers illustrated in this ad. They are all the result of rough ideas that originated with the men in plants after a basic installation, then developed by our engineers. All ideas were stimulated by the powerful Dempster-Dumpster and its flexibility in picking up, hauling, setting down or dumping anything that needs transporting, at lower cost.

One man, the driver, and a few simple hydraulic controls in the cab of a Dempster-Dumpster, will become indispensable in your plant. It is just that in hundreds of plants of every description throughout the nation. Let one of our representatives give you details of installations. Manufactured exclusively by Dempster Brothers, Inc.

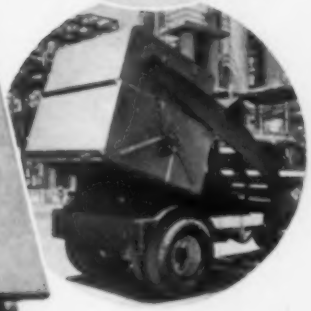
Above container is built with cast iron liner. The holes in outer wall are for cooling.

Here is one of several special drop bottom type containers equipped with couplers and ball bearing trucks for operation in train on rails.

THE DEMPSTER DUMPSTER SYSTEM

DEMPSTER BROTHERS

so many plants find the indispensable...



Two photos above show how all containers, regardless of design, are picked up and hauled. At destination materials are dumped from drop bottom containers as shown at left . . . from Tilt and Skip Type Containers by tilting. Any load, of course, may be set down intact.

This is a special adaptation whereby waste zinc slurry is pumped into two containers, which serve as settling tanks, enabling majority of the water to be decanted before sludge is transported and dumped at waste basin.

Tank Type Containers are available with or without casters in steel, aluminum, stainless steel, etc. Capacity ranges up to 1,200 gal. They may be lined with rubber, lead, highly resistance coatings, etc.

This is a master container with three 2 cu. yd. insert containers. Each insert container is provided with casters, counter-balanced spring-hinged lid for loading and dumping.

585 DEMPSTER BLDG., KNOXVILLE 17, TENNESSEE

EDITORIALS . . .

You Can't Sit on Your Hands

THE special report on catalytic reforming in this issue points up one amazing feature of the petroleum industry which has long been a pet but private subject of conversation with us.

And that is this: If you're in the field of researching and developing new petroleum processing techniques, don't count on merely building a better mouse trapper (or hydrocarbon reformer), and then sitting back and basking in the glory of your achievement. You may develop a new process, better than anything previously available—but sooner or later (and usually sooner) someone else will come along with something just as good or even better. Witness catalytic reforming. Universal Oil Products announced its Platforming process in 1949; today there are ten competitive catalytic reforming processes available — and all competing with one another.

That competitive process development makes it difficult for an oil company to get a payout on its research expenditures merely by giving its operating department an edge over other refiners. The edge is likely to dull very quickly as other researchers come up with and patent their own versions of similar processing techniques.

The petroleum industry learned long ago that the real payment in research comes not from using a new development for its own operating advantage — but from licensing its competition to use the same process or product or whatever it might be for a reasonable royalty fee.

More and more, we believe, the petroleum company which engages in any amount of research is going to have to "market" the results of that research. More companies are going to have to build up their market research and product development staffs to exploit what the research labs come up with that has any practical possibilities — to find markets for the research results before they become too old to sell.

Take a Look at Your Distillates

OVER the years refiners have spent large sums in research to improve their motor gasolines, although the competition for the markets for these fuels is entirely among the oil companies. There's little likelihood so far that coal will be used as an automotive fuel —or natural gas, or the atom.

On the other hand, comparatively little attention has been directed toward improving the distillate fuels—where competition with other energy sources does exist. It's quite possible that the coal people (if they'd ever invest some serious money in research) could come up with techniques that would put coal back on the locomotive and even in the home.

We're not thinking of research aimed at making better quality products through more involved processing —which would probably lead only to more expensive products. We're thinking of studies aimed more at finding out how to improve product utilization, how to get more value out of present products, how to make low-quality products do a satisfactory job. We're thinking of research aimed at finding better consuming equipment, less expensive processing tools, new quality-improving additives.

Research on the distillate fuels directed toward these goals could well be a profitable venture. It could serve not only to protect present markets from competing fuels outside the petroleum field, but might also point to entirely new markets.

Your Company Has a Job to Do

WE'D like to provide you with some recommended reading. It's a reprint of a special series of editorial messages on the financial plight of our colleges and universities and what can be done about it.

You may have read some of these messages; all of them appeared in PETROLEUM PROCESSING over the past year. They develop the theme that our educational institutions — particularly the independent, privately endowed ones—are caught in a destructive financial squeeze. This squeeze has been caused by two factors: (a) price inflation since 1940 has cut in half the purchasing power of endowment income; (b) new endowments have been greatly reduced by the heavy taxes on the incomes and estates of wealthy persons.

The recommended solution: a general movement on the part of business firms to go to the financial aid of higher education. Much has already been done along these lines—but mostly by the large corporations. The job is too big a one, however, to be handled by a small number of business firms, no matter how large they are, or how bold and ingenious their programs.

It is a job which requires the participation of all business firms, both large and small alike. It is a job in which all business firms have a stake. What happens in and to our college and university classrooms will have a decisive effect in shaping the future of the United States—and could cause *or prevent* a national disaster.

We strongly recommend that you reread this series of messages, and will gladly send you a report—no charge. In fact, we will make it so easy to get a copy that you cannot afford not to read it. Simply circle No. 80 on one of the reply cards between pages 1252 and 1253 in this issue, fill in your name and address, and send us the card. If you want an extra copy to pass on to your boss, circle No. 79 as well.

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Above photograph courtesy of QUAKER STATE OIL REFINING CORP.

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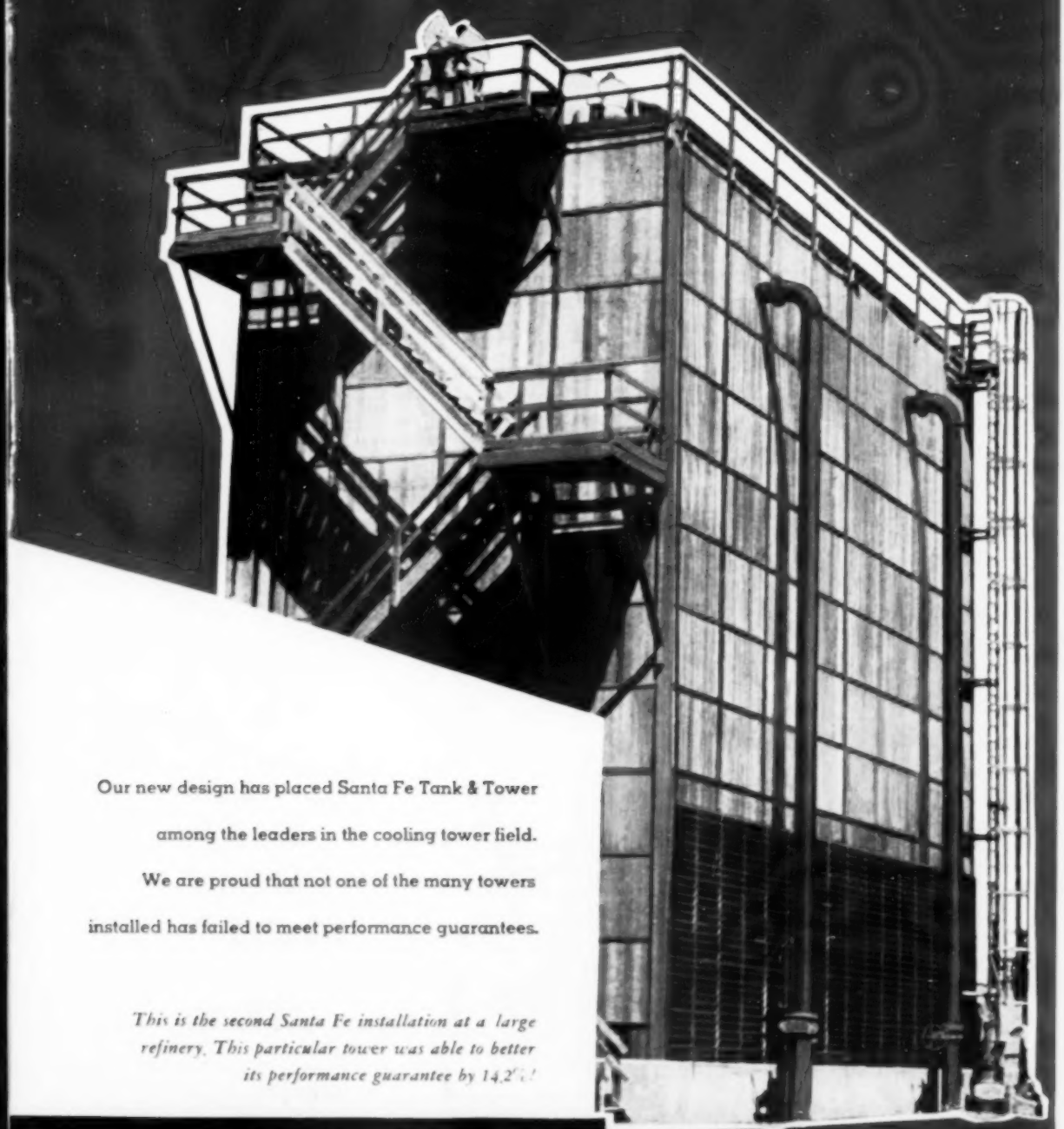

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